YUMA (ARIZONA) DRAINAGE-GROUNDWATER PROBLEM

HEARING

BEFORE THE

SUBCOMMITTEE ON IRRIGATION AND RECLAMATION

OF THE

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS UNITED STATES SENATE

EIGHTY-FOURTH CONGRESS

SECOND SESSION

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YUMA (ARIZ.) DRAINAGE-GROUND WATER PROBLEMS

NOVEMBER 8, 1956

UNITED STATES SENATE,
SUBCOMMITTEE ON IRRIGATION AND RECLAMATION OF THE
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Yuma, Ariz.

The Subcommittee on Irrigation and Reclamation, Senate Committee on Interior and Insular Affairs, convened at the Stardust Hotel, Yuma, Ariz., at 10 a. m., November 8, 1956.

Present: Hon. Clinton P. Anderson, Senator from New Mexico, chairman; and Hon. Barry Goldwater, Senator from Arizona.

Also present: Hon. Carl Hayden, Senator from Arizona; and Hon. Stewart Udall, Representative, Second District, Arizona.

Also present: Mr. Goodrich W. Lineweaver, committee assistant for the Subcommittee on Irrigation and Reclamation, Senate Committee on Interior and Insular Affairs; and Mr. E. D. Eaton, staff consultant for the subcommittee.

Senator ANDERSON. This hearing on the drainage or seepage and waterlogging, and ground-water problems of the Valley Division, Yuma project, will come to order.

This hearing or conference is called at the request of Arizona's two very distinguished Senators, Senator Hayden and Senator Goldwater. The purpose is to get out on the table all available facts and technical conclusions relating to longstanding problems confronting the Yuma County water users in connection with drainage, seepage, and waterlogging of project lands. From my experience and observation of conditions in the Middle Rio Grande are of New Mexico, I am somewhat familiar with similar conditions and problems which we observed on our brief inspection by automobile of some of the irrigated areas affected around Yuma.

The Yuma problem has been before the Department of Interior, and particularly the Bureau of Reclamation, for many years. It came before our subcommittee at a hearing on June 30, 1955, in connection with S. 1689, a bill to authorize the Secretary of the Interior to execute a repayment contract with the Yuma-Mesa Irrigation and Drainage District of the Gila project. The contract authorization was recommended and the legislation enacted without reference to the seepage problem outside of that district.

At that hearing the committee took testimony with respect to alleged damage by seepage from Yuma-Mesa lands to the Valley Division. The testimony was in sharp conflict as to responsibility, the extent of responsibility, or the source of the problem.

The committee concluded that further and independent analysis of the situation was essential before a justifiable determination could

be made. We recommended that the Secretary of the Interior take appropriate steps to get independent technical views with respect to the sharply controversial subject which had been studied by the Bureau of Reclamation and the irrigation interests over a long period of years. The committee suggested that the Secretary retain independent consulting engineers to study, analyze, and report on the vast volume of engineering and other technical data which have been accumulated by the Bureau of Reclamation and other interests in connection with this situation.

As a result of this recommendation, the Secretary of the Interior first instructed the Geological Survey to make an analysis of available technical and other data and reports. Following the submission of the Geological Survey report, the Secretary retained two outstanding authorities on drainage and related problems to make a further analysis and a report.

The committee understands that at least one of these experts (Messrs. Tipton and Jacob), named by the Department, as well as Geological Survey experts, are available today to summarize their findings, which were submitted in writing to the Department on November 1, and which will be made a part of this record. In view of the circumstances and the paucity of time, Messrs. Tipton and Jacob will be major witnesses today, as will also Messrs. Brown or Harshbarger, of the Geological Survey. Mr. Maierhofer, of the Bureau of Reclamation, is also on the list of experts to testify.

Because of the time element for the hearing today, the Chair requests the cooperation of all concerned. The local irrigation interests or water users' associations that desire to make a statement will, of course, be heard. It is suggested that each organization have one spokesman to make the presentation.

Incidentally, testimony today will be limited to the situation with respect to lands in the Yuma Valley, its causes and effects, and any possible remedies that may be suggested. We will not have time to go into extraneous or collateral matters.

Witnesses are requested to summarize their views and submit written statements which will be incorporated in the record that will be printed as soon as practical after the material is forwarded to Washington. In addition to testimony taken here today, pertinent material submitted at the hearing in Washington on June 30, 1955, will also be incorporated in the record, which will remain open for supplemental statements until November 25.

First, we will be glad to hear from the distinguished chairman of the Senate Committee on Appropriations, the Honorable Carl Hayden. Then our other colleague on the committee, the distinguished junior Senator from Arizona, the Honorable Barry Goldwater, will be heard, followed by Representative Stewart Udall, in whose district Yuma is located.

I don't have to introduce Carl Hayden, quite obviously, to an Arizona audience. I merely want to say that all of us in Washington are delighted to bask in his sunshine and take part in the profits that he brings to us because of his long acquaintance in Washington and his very skillful way of handling legislation. But as a neighbor, Carl, I want to say to you that it is a very distinguished occasion when I can sit next to the new dean of the United States Senate. Senator Hayden.

STATEMENT OF HON. CARL HAYDEN, UNITED STATES SENATOR FROM THE STATE OF ARIZONA

Senator HAYDEN. Well, this hearing was arranged, as Senator Anderson said, to try to develop the facts. And the way to do that is not to have the United States Senators do very much talking. We want to get the experts on this problem. It has been a long and aggravated controversy. We do hope that facts which can be developed will settle it.

I am very grateful indeed that Senator Anderson could find the time to come down here as chairman of the subcommittee of the Senate Committee on Interior and Insular Affairs to give this subject the attention which at least we locally here feel it deserves.

Thank you, Senator Anderson, for being here.

Senator ANDERSON. Thank you.

Next, I am very happy to call on another man that doesn't need any introduction. I should be the one, I think, being presented in a strange audience like this. But it has been a very fine pleasure to all of us on the Senate Committee on Interior and Insular Affairs to have as one of our members, and one of our working members, the junior United States Senator from Arizona, Senator Barry Goldwater.

I can say to you that to me it has been a great pleasure to have him associated on the committee. Senator Murray, as many of you know, was ill for quite a while and a great deal of the work of the committee fell to me, and it was a pleasure to have working members of the committee, men who would take the time to come and sit there day after day when we have had long hearings.

I therefore am very happy to now present to you your junior United States Senator, Senator Barry Goldwater.

STATEMENT OF HON. BARRY GOLDWATER, UNITED STATES SENATOR FROM THE STATE OF ARIZONA

Senator GOLDWATER. First, Senator Anderson, I want to add my appreciation to those expressed by Senator Hayden for your coming here today and conducting this hearing. As Carl has told you, the only way we are going to settle this is by a hearing like this where we can have both sides of the argument and hear the experts, the engineers and the technicians who have studied this. After that, I am sure that Senator Anderson will go into it deeply with those of us in Washington on the committee and the others from Arizona who are not on the committee.

I am hopeful that the problem which we are discussing today can be solved in a manner that will be satisfactory, not only to all of the parties affected at the present time, but to all the citizens of Arizona. I am going to ask this committee and the Bureau of Reclamation to examine the whole water structure of the surrounding area with an eye to not only alleviating the seepage problem, but satisfying our obligations under the Mexican water treaty with water that is otherwise useless. Water is the biggest single problem which we face in Arizona and it is my earnest hope that the information which will be forthcoming as a result of this hearing may go a long way toward a solution to our constant water shortage.

I am very happy to be here today. I want to apologize for having to leave early. There is an event taking place in Phoenix today over which I had no control. Our family, after starting a business in Yuma

County nearly a hundred years ago, is going to open our newest and biggest store in Phoenix today and I have to be up there. So if you will excuse me, I will have to leave shortly after the hearing starts. But I am glad to be here and I again want to thank you, Clint, for coming here from New Mexico to give us of your time.

Senator ANDERSON. Thank you.

I am very much interested in young people taking an interest in Government. I am as pleased as I can be to see these young folks from the high-school civics class here trying to find out what is going on. They are seated in the back of the room, and I would hate to think that we are discourteous to them and didn't give them a chance to hear what was going on.

Now the last member of our congressional group here is a Member of the Congress from this district, who has won himself a great many friends in the Congress in Washington. When I first went into the House of Representatives, not quite as long ago as Carl Hayden did, but a good many years ago, the then Speaker of the House, Sam Rayburn, called me to one side and said, "It doesn't matter how hard you want to work for your people at home in your district. You can try as hard as you want to, but if you don't serve the constituency out on this floor of 435 Members, it won't do you any good to try to serve your constituency at home. You have two constituencies, and if you work hard with the 435 Members of the House and get their respect and their esteem, you will automatically be able to take care of your constituency at home by being able to do things for them."

I want to say to Congressman Udall that I think he has learned that lesson very, very well, that he serves his other fellow Members of the House in fine fashion, working with them, earning their respect and their esteem. As a result of that—I assume, since the election is over I don't have to worry about this being political or not—I assume that the people at home recognize that he serves his constituency at home also.

It is a great pleasure for me to present to you someone whom you know much better than any of us, Congressman Udall.

STATEMENT OF HON. STEWART UDALL, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF ARIZONA

Congressman UDALL. Thank you, Senator Anderson. And I must say, since Senator Hayden and I were on the ballot 2 days ago, we think Yuma is a very nice place.

I am glad that you would let me sit with the Senate committee today. I am a member of the corresponding House Committee on Irrigation and Reclamation, and more or less sit here as a representative of that group.

This has been a very troublesome problem; it is a deepening problem. Senator Goldwater and Senator Hayden and I all have been in the past thoroughly advised by local people about it, but now we have gone out in the field and studied this particular problem.

We are here today, as Senator Hayden said, in search of the facts. As matters now stand, the chief burden of this condition falls on a particular group, namely, the farmers in the valley. The question we are attempting to determine, of course, is whether part of that burden belongs elsewhere, on the Bureau of Reclamation and the Congress, or on some of the other interests here. I will be very interested in hearing

the testimony, and I am sure that after we have digested it, that if there is a responsibility which should be lodged on the Congress and on its committee, that those of us who are here and take part in the hearing will see that our colleagues who are not present are thoroughly informed of the facts in this situation.

I am happy to be here, and I will listen with great interest to the proceedings. Thank you.

Senator ANDERSON. Now we will start with our list of witnesses. I think, in the interest of trying to make it possible for as many people to hear as possible, that we will ask our witnesses to talk from this end of the table.

The first witness will be Ernest Johannsen, Yuma Valley Water Users Association.

STATEMENT OF ERNEST M. JOHANNSEN, PRESIDENT, YUMA COUNTY WATER USERS ASSOCIATION

Will you please identify yourself?

Mr. JOHANNSEN. I am Ernest M. Johannsen, president of the Yuma County Water Users Association. My purpose in making this statement on behalf of the association is, first, to emphasize the seriousness of our drainage problem and, second, to suggest a program to correct the problem.

We are deeply indebted to this committee for the recommendations contained in their report (Rept. No. 1072) on Senate bill 1689, 84th Congress. The United States Geological Survey report and the report of private, independent engineers, which were both contained in the recommendations, point up the existence of the drainage problem and the necessity for its solution.

We are especially grateful to the committee for calling this hearing, and this date and place are most appropriate for several reasons. First, it has enabled your committee to make a firsthand inspection of one of Reclamation's oldest and most successful projects. You have seen waterlogged farmland and an artesian well, both within a stone's throw of surface drainage canals, augmented by sump pumps.

We call to your attention the fact that no drainage canals or sump pumps existed in this area prior to 1945.

Second, we have reached the critical point financially in trying to cope with this problem by the direct annual operation and maintenance assessment. We do not mean to imply that we are ineligible for a loan to correct this problem, as a loan was suggested in a Washington conference last January, but our farmers are not inclined to approve a loan for correcting this problem, since it is not caused by irrigation operations on this project.

Third, something must be done now, because water is literally boiling up under our feet. It must be removed if agricultural production is going to continue in this eastern edge of the valley division.

Since we are not financially able to correct the drainage problem and we are seeking nonreimbursable funds for its correction, I feel you are entitled to know what we have done with our own resources to solve the problem and why it is necessary to seek outside assistance. For these reasons I want to briefly review the history of our drainage problems.

The valley division, which the association serves, instituted a normal drainage operation about 40 years ago. This was a necessary result of our application of water to the land, and we have recognized and accepted it as a part of our normal operation and maintenance program. This exhibit, No. 1, shows in heavy black lines our surface drains, which operated successfully until about 1940, or for a period of 24 years. Tributaries flow into this main drain and all the water which reaches the main drain flows, by gravity, down to the Mexican boundary, where our pumping plant lifts it approximately 12 feet to the point of delivery to the Mexican irrigation system canal.

Senator ANDERSON. May I interrupt to say for the record that all exhibits presented at the hearing will be placed in the permanent files of the committee; however, most of the maps and charts cannot be included in the printed hearings.

Mr. JOHANNSEN. This exhibit also shows in a green line where a new drainage canal was started from the main drain and it reaches into this area south and east of Somerton to correct a high ground water condition that developed about 1940.

In 1945, another new drainage canal was started and it penetrates into the Big Bend area, as shown in red on this exhibit. It was at about this time (1945) when drainage in the valley division ceased to be a normal operation and developed into such a problem along the east side of the valley division that it could no longer be controlled by surface drains.

In 1946, the first sump pumps were installed in surface drains as shown in the black open squares on exhibit No. 2 to help remove water that would not flow out by gravity. This water was, and still is, pumped into our distribution system and is reused for irrigation water. This plan of operation soon proved inadequate, and in 1947, eight drainage wells were installed. These wells, shown on exhibit No. 1, were approximately 100 feet deep and produced 2 to 3 cubic feet per second flow of water. This water was also pumped into our distribution system and reused for irrigation.

By 1951, it became apparent that these eight small drainage wells were not adequate to keep our water table down to satisfactory levels. Since that time six of these wells have been abandoned leaving only wells Nos. 1 and 2.

In 1954 we installed the first deep well which extends down into the coarse gravel underlying the valley division.

In February of 1955, we formulated a definite plan of action. This plan included the installation of nine wells and the construction of a pumping plant for removing water from the central part of the valley, going west into the Colorado River. Since 1954, we have installed a total of six deep wells, as shown on exhibit No. 2, and these deep wells have proved to be the only effective method of lowering the high ground water within the range of each well along the east side of the valley division. The wells are 24 inches in diameter and approximately 200 feet deep. Each well produces, on an average, approximately 10 second-feet and, in terms of acre-feet, as much as 7,000 acre-feet per year. The plan formulated in 1955 is already inadequate and it is obvious at the present time that the construction of the three additional wells is far from enough to correct our drainage problem. Meanwhile, the west side of the valley is contributing

so little water that one of the drains on the west side has gone dry.

The drainage situation has become so acute that it has been necessary to adopt a policy of economic assistance to affected farmers by cancellation of the operation and maintenance charges, where acreage goes out of production, due to high ground water. Approximately 650 acres along the east side of the valley are not being charged operation and maintenance assessments.

Exhibit No. 3 is a depth to ground water map of the valley division, completed in December of 1955. It indicates in colors the total area affected, being that area having a water level of 6 feet, or less, in which we regard 4 feet or less, shown in red, as critical due to excess salinity. This next exhibit, No. 4, indicates the location of all parcels of land using more than 5 acre-feet per acre in 1955. Note the lack of correlation between areas using more than 5 acre-feet and areas having a high water table.

The next exhibit, No. 5, indicates our drainage water outflow at the Mexican boundary as measured at our boundary pumping plant. It goes back to 1935 and indicates the upward trend of water removal. Note the pumping prior to 1945 and after 1945. The area shown in red indicates the water from the sumps and drainage wells. While most of the water from the sumps and drainage wells is reused for irrigation, it is nevertheless drainage water, and is so indicated on this exhibit. The black line indicates the net acreage irrigated. Farmers are objecting to the well water for irrigation because of salinity and also because our water right is based on gravity-diversion of Colorado River water. The only reason this water is not dumped back into the river is that we cannot afford to build facilities to transport it to the river.

The increasing financial burden to the association, attempting to cope with the rising ground water table, is illustrated by the fact that in 1945, of a total budget for operation and maintenance of the entire project of approximately $201,000, less than $25,000 was expended for drainage control, or about 12½ percent. During the past 10 years, the association has spent in excess of $1,500,000 for drainage. For 1956 we will spend, in addition to administrative, general and plant expenses, more than $250,000 for drainage, which is more than we will spend for distribution of water. This is more than 50 percent of our total budget for 1956. Since we irrigate entirely by gravity diversion from the Colorado River, we should have very reasonable water costs in the valley division, but yet, according to public notices, we have one of the highest operation and maintenance assessments in the entire Yuma area.

I would like now to point to a possible means of correcting our drainage problem. I am advised by our engineer that the most logical plan for removal of the excess drainage water is to construct a concrete-lined canal along the escarpment of the mesa, and by the installation of additional wells and pumps to deliver the water, through this canal, to the boundary. A rough estimate of the cost of constructing this canal is $3 million. Our engineer estimates that an additional 25 deep wells, of the type already installed, will be necessary to adequately drain our lands and maintain a proper ground water level. The entire cost of the plan is probably less than $4 million. We feel,

in good conscience, that we are justified in seeking financial assistance for the correction of the drainage problems for the following reasons:

First, we believe engineering reports to be offered today will show that we are not responsible for the aggravated drainage problem which threatens the whole east side of the Valley Division.

Second, unless this critical situation is corrected the economy of the entire Yuma area will be threatened. The total value of the crops produced by the Valley Division in 1955 was $14,500,000, while the total value of all crops in southern Yuma County for 1955 was $24,750,000.

Third, the disposition of the drainage water along the lines suggested would result in an additional credit accruing to the United States against the required deliveries to Mexico under the Mexican treaty. At the present time, and solely at our own cost and expense, we are returning through our drainage system and wasteways a very substantial amount of water into the limitrophe section, where it is measured by the International Boundary and Water Commission. In 1955 this amounted to about 156,000 acre-feet, but only 38,740 acre-feet was charged to the treaty. We believe that this could be——

Senator ANDERSON. I don't follow that; I don't follow what you said. You said 156,000 acre-feet, but only 38,740 was charged to the treaty.

Mr. JOHANNSEN. That's right.

Senator ANDERSON. Explain that. Why wasn't it all charged? If the water was delivered, why didn't it fulfill the treaty requirements?

Mr. JOHANNSEN. Effective January 1, by agreement between the——

Senator ANDERSON. What year?

Mr. JOHANNSEN. January 1956. Effective January 1, 1956, by agreement between the American and the Mexican section of the Boundary Commissions, an agreement was made that the water crossing the boundary through the pumping plant would be regarded as limitrophe section water. Prior to that time this water was not charged to the treaty.

Senator GOLDWATER. Is it now?

Mr. JOHANNSEN. It is being charged now.

Senator GOLDWATER. If you deliver 156,000 acre-feet in 1956, it will be charged against the treaty?

Mr. JOHANNSEN. That's right.

Senator ANDERSON. It will be regarded as fulfillment of the treaty obligations of the treaty between the United States and Mexico?

Mr. JOHANNSEN. That is right.

Senator ANDERSON. Now, could you go back just a moment. You show that in 1937, for example, very little water was delivered.

Mr. JOHANNSEN. Yes.

Senator ANDERSON. 1936, none was delivered. Now you are delivering——

Mr. JOHANNSEN. No. This is the figure of water pumped at the boundary, 40,682 acre-feet in 1936.

Senator ANDERSON. And 105,000 acre-feet pumped in 1955?

Mr. JOHANNSEN. That's right.

Senator ANDERSON. So that actually by your pumping you have increased the amount of water to where it is 2½ times what it was in 1936?

Mr. JOHANNSEN. Yes.

Senator ANDERSON. And in 1956 you anticipate how much?

Mr. JOHANNSEN. We have some conditions in 1956 which will affect the outflow and it may not register an increase over 1955. We shut down our drainage wells for a period of 30 days for engineering reasons, to obtain certain engineering data, and it may have an effect on the overall pump out for the year 1956.

Senator ANDERSON. However, there is a very substantial amount of water to be developed and delivered in fulfillment of those obligations?

Mr. JOHANNSEN. Yes.

Senator ANDERSON. Is it your theory that if you did not pump that water it might flow down underground and be recovered by Mexico if it wished to? I am just trying to find a justification for building a $4-million canal here. If this fulfills the requirement, then you have some justification for it. You are fulfilling a Federal contract?

Mr. JOHANNSEN. Yes. I will approach that as I advance in my statement.

Senator ANDERSON. All right.

Mr. JOHANNSEN. We believe that this could be increased with the installation of the concrete-lined drainage canal and the additional wells necessary to provide the proper balance for our water table by 150,000 acre-feet per annum, or possibly a great deal more. Thus, there would be a contribution of approximately 300,000 acre-feet of water per year toward the Mexican treaty requirement, or 20 percent of the total requirement. This is of interest to the entire basin and, in fact, to all sections of the West using water from the Colorado River, and we believe this end alone justifies the expenditure. The water so delivered, especially in these times of water scarcity, is cheap water when related to basin requirements.

The estimated $4-million capital outlay, plus the annual operation and maintenance cost, would permit the retention of additional storage annually in Lake Mead and represents substantially more than the 300,000 acre-feet of water we are referring to when we take into account the stream losses from Lake Mead to the limitrophe section where the water is measured. We invite your consideration of the international aspects of this problem.

Senator ANDERSON. Does the treaty have anything to do with the amount of water in Lake Mead or delivery at the border?

Mr. JOHANNSEN. Delivery at the border.

Senator ANDERSON. Well, then, we all recognize that there are evaporation losses in Lake Mead, there are losses in transportation down to the border. It is your contention that in order to get 300,000 acre-feet at the border we have to have much more than that in Lake Mead?

Mr. JOHANNSEN. That's right.

Senator ANDERSON. Therefore, it is a very substantial contribution from that standpoint?

Mr. JOHANNSEN. We are replacing what would have to be that contribution.

We are hopeful that the testimony of the appointed engineers will provide the engineering information necessary for a proper approach to correcting this problem.

We conclude our statement by expressing our appreciation for the continued interest of the committee regarding our drainage problem.

Senator ANDERSON. Senator Hayden, do you have any questions?

Senator HAYDEN. No questions.

Senator ANDERSON. Congressman Udall, do you have any questions?

Congressman UDALL. Yes, Senator, I would like to ask a few questions. With reference to this canal proposal, have your engineers made any detailed study of that, or is this just a horseback estimate?

Mr. JOHANNSEN. This is an estimate that is based on contract awards on similar type construction in the Yuma area, projected out for the required distance necessary to transport the water.

Congressman UDALL. We are all familiar with the small-projects bill that was passed by the last session of Congress. The figures you mention are under the $5 million limit. Have you given any consideration or thought to whether this would qualify under that recent legislation?

Mr. JOHANNSEN. No; we haven't.

Congressman UDALL. If you don't understand it, I think I can tell you that that provides for interest-free money and, of course, that in itself would provide some assistance. But let me ask one other question.

Does your irrigation district have any opinion, or are you prepared to make a statement today, with regard to what portion of that obligation the irrigation district should bear and what portion should be borne by other interests, including the Government; or are you going to await the testimony before you furnish us with a figure on that?

Mr. JOHANNSEN. We are not prepared to make any statements because they might open controversy, and it is our thought that this hearing is for the purpose of resolving a controversy. Our testimony might be considered partial and, as such, we want to listen to testimony offered by members of the committee and——

Congressman UDALL. Let me ask this hypothetical question just solely that we may have something in the record. Assuming that this committee, relying on the expert testimony, were to determine that the outside responsibilities, say, were 20 percent, and that your district should bear 80 percent of the cost of such a structure and works, would you be prepared to go ahead, perhaps if you could get interest-free money under the small-projects bill, or is this something where you would require more assistance than that?

Mr. JOHANSEN. I am not able to commit the association on a statement of that type.

Congressman UDALL. All right. Let me ask one other question. What is the annual amount—perhaps I did not listen to your testimony as carefully as I should—that you are now spending to tackle this drainage problem for your pumping?

Mr. JOHANSEN. It is difficult to state an exact figure. We set up a budget and we try to operate within areas defined in that budget. But as I pointed out in my testimony, the budget item for drainage is in excess of the budget item for water distribution. This year we have drawn on reserve funds to increase the amount of expenditures for drainage, and assuming that administrative and plant expenses would be divided in direct proportion, we are spending more money for drainage than we are for distribution of water.

Congressman UDALL. And the picture is getting worse instead of better, I believe you testified?

Mr. JOHANSEN. Yes.

Congressman UDALL. But, of course, under present conditions, where you don't have a concrete-lined canal, part of the water that

you pump out of the ground and put in the canal goes right back into the ground—a substantial portion of it. So that under those conditions are you completely solving your problem?

Mr. JOHANSEN. I don't follow your question. Would you restate that.

Congressman UDALL. The point that I am trying to make is that a part of the water that you pump out and put in a canal, also goes back into the ground, since the canal isn't concrete lined. Therefore, is your pumping operation a hundred percent successful under such conditions?

Mr. JOHANSEN. No. Let me try to clear up what you are asking there. The water is put back into our distribution system and reused for irrigation.

Congressman UDALL. Yes.

Mr. JOHANSEN. Our canal loss——

Senator ANDERSON. Just a minute. We looked at some pumps this morning and they were pumping water back into ordinary dirt ditches. Now that water disappears down into the ground again. That is what Congressman Udall is trying to state.

Mr. JOHANNSEN. Are you referring to the drainage canals?

Congressman UDALL. Yes.

Mr. JOHANNSEN. Or the distribution canals?

Senator ANDERSON. Your drainage canals is what I had in mind.

Mr. JOHANNSEN. I beg your pardon. I misunderstood your question.

Just recently, in fact this year, we are dumping that pumped drainage water into the drainage canals, that's true, and it is probably having the effect of loading back into our system rather than reaching the boundary pumping plant.

Congressman UDALL. That is the point I want to establish. That is all I have, Senator Anderson.

Senator ANDERSON. How many acres are in the Valley Division?

Mr. JOHANNSEN. Approximately 50,000 irrigable acres.

Senator ANDERSON. What is it costing you now to pump from the standpoint of just pumping out this excess water?

Mr. JOHANNSEN. I would give you this figure in this way: Our annual operation and maintenance assessment this year is $13. Based on apportioning administrative and general and plant expenses equally between the 2, that would incorporate a pumping cost of $6.50 an acre.

Senator ANDERSON. You must know what it costs to run these pumps.

Mr. JOHANNSEN. I might illustrate——

Senator ANDERSON. It surely doesn't cost $300,000 a year to run these pumps.

Mr. JOHANNSEN. No, it doesn't.

Senator ANDERSON. What does it cost?

Mr. JOHANNSEN. Capital costs are incorporated into that figure.

Senator ANDERSON. I run three pumps. You run how many?

Mr. JOHANNSEN. We are only running six at the present time.

Senator ANDERSON. What does it cost you to run them?

Mr. JOHANNSEN. Will this help to answer your question? It takes less electricity to pump this amount of water, 105,000 acre-feet, than it does to pump the 31,000 acre-feet; it takes about 2,750,000 kilowatt-hours of energy.

Senator ANDERSON. I am trying to get a figure for another purpose entirely. You want to add how many new wells along that canal?

Mr. JOHANNSEN. We talked about 25.

Senator ANDERSON. Now if I can't find out what it costs to run the present pumps, I can't find out what it is going to cost to run those 25 pumps.

Mr. JOHANNSEN. I would have to refer you to our engineering department for a cost breakdown. I am unable to give you that figure to a reasonable degree of accuracy.

Senator ANDERSON. I wish you would furnish it. My pumps aren't as large as yours, but I flow about 2,200 gallons out of my main pump. I pump it by natural gas. I know what it costs me to pump it when I run it full time. You are running these wells almost all the time. Surely somebody keeps track of the electricity going into it and knows what it costs, plus reasonable maintenance to run those pumps; isn't that right?

Mr. JOHANNSEN. Yes.

Senator ANDERSON. Will you furnish me that figure?

Mr. JOHANNSEN. Yes; we'll try to. But, Mr. Chairman, we are new in the pumping business and——

Senator ANDERSON. Not if you have been pumping since 1935, you aren't new.

Mr. JOHANNSEN. We are new in these big wells. They are comparatively new. Our system of keeping accounts does not include a depreciation schedule. We operate on a cash basis. I will try to give you a breakdown which includes only the normal operation.

Senator ANDERSON. The depreciation schedule doesn't compare with the current cost; does it?

Mr. JOHANNSEN. No.

Senator ANDERSON. Now why can't we get the current cost? How much does it take to run it for a year? I can put depreciation after that.

Mr. JOHANNSEN. I will furnish you that figure. I am unable to give it to you now.

(See supplemental statement, p. 65.)

Senator ANDERSON. I have one pump on my place that is 25 years old. There isn't an awful lot of depreciation. These big, well-managed pumps last a long time. What I am trying to find out is what the financial burden to the United States Government would be if we said, "Very well, we'll install a bunch of pumps." Will you furnish that to me?

Mr. JOHANNSEN. Yes.

Senator ANDERSON. All right, thank you.

Now, Mr. Lee Bradley or Mr. W. R. Whitman, representing the Yuma Irrigation District. Will you just identify yourself?

STATEMENT OF LEE S. BRADLEY, PRESIDENT, BOARD OF DIRECTORS, YUMA IRRIGATION DISTRICT

Mr. BRADLEY. My name is Lee S. Bradley, and I am president of the board of directors, Yuma Irrigation District. In the interest of brevity, we have prepared a brief statement to present, but prior to launching on that I would like to distribute maps to indicate the general layout of our valley.

My name is Lee Bradley, as I have stated. I am president of the Yuma Irrigation District, which was organized in 1919 as a political subdivision of the State. This district is often referred to as the South Gila Valley. The cultivation of district lands has generally increased until presently about 12,000 acres of irrigable land are included within its boundaries. The district lies along the south side of the Gila River, immediately east of the city of Yuma, and north of the Yuma Mesa. All but a comparatively small portion of district lands are irrigated by electrically operated pumps.

Over a period of years the underground water level in the area remained practically static other than seasonal variations which seemed to be due to seasonal flows of the rivers, and curtailed or increased pumping. In the late 1940's and early 1950's, the static level of underground water began to rise. As an example, the static water level in my own well stood at 36 feet 1½ inches on the 14th day of April 1940. On the 16th day of April 1950, the same well stood at 28 feet 11¾ inches, while approximately 5 years later, on the 20th day of March 1955, the static level of this well was up to 20 feet 5¾ inches. Relatively the same increase in the water level exists throughout the district. Careful records have been kept on both water level and increased mineral content and are made available to all persons concerned with the problem. In some parts of the district, the ground water is within 6 feet to 9 feet of the surface.

There are various nearby agricultural areas irrigating with gravity water from the Colorado River. These include the North Gila Irrigation District, lying to the north of our district, the Wellton-Mohawk project, lying up the Gila River to the east, and the Yuma-Mesa area, which adjoins our district on the south, and the elevation of which is several feet above the lands of the district.

From the facts which we have been able to obtain and from the advice of our consultants, it seems reasonable to conclude that the rising water table beneath the Yuma Irrigation District lands is directly attributable to Colorado River water being brought into the area.

We feel that the problem is rapidly approaching an emergency status, not only from the standpoint of our own district, but from the standpoint of the Yuma area generally. Any curtailment of agriculture in Yuma County due to waterlogging reacts to the disadvantage of the entire area and to the cause of reclamation.

Without attempting to examine or determine any of the complicated facets of cause and responsibility, it is our considered judgment that the Yuma Irrigation District and its landowners are not responsible for the existing condition within the district boundaries, inasmuch as they have irrigated almost exclusively with water pumped from the underground supply of the area, which, of course, results in a depletion of the underground water rather than increasing its level.

Senator ANDERSON. Before you get through with your testimony, will you say who you do think is responsible, or would you have any opinion on it?

Mr. JOHANNSEN. The contiguous areas, we would presume, sir.

Senator ANDERSON. All right.

Mr. JOHANNSEN. The officials of the Yuma Irrigation District were sufficiently concerned with the trends of the increasing water level and the increasing salinity of the water to employ a consulting engi-

neer experienced in drainage matters to advise them concerning the underground water conditions in the South Gila Valley. The consultant chosen for this task was J. R. Iakisch. Mr. Iakisch was chosen for the study and advice by virtue of his long experience in drainage matters and his familiarity with the problems in the Yuma area. In order that you and others who may read the records of this proceeding may be assured of Mr. Iakisch's qualifications, I should like to briefly relate some of his history, employment and experience on drainage matters.

He graduated in 1911 from the University of Wisconsin with a degree in civil engineering. His career on drainage matters began the year following and continued for over 40 years in the Drainage Division of the Bureau of Reclamation. During his last 8 years, he was senior engineer and head of the Bureau's Drainage Division.

Mr. Iakisch retired from the Bureau of Reclamation in 1948 but has continued to be active in his field as a consultant for many and varied reclamation projects, both here and abroad. He has recently completed drainage work on projects in the Philippine Islands, Israel, Argentina and Puerto Rico.

I feel sure that he is one of our country's foremost drainage engineers and is eminently qualified to assist us and your committee in connection with the Yuma area problem.

The report which Mr. Iakisch prepared for the Yuma Irrigation District was completed and published in February of this year. It has received fairly general circulation, and I understand it is now a part of the records and files of this committee.

Rather than go into the Iakisch report in detail I prefer only to call the committee's attention to the report and have asked Mr. Iakisch to prepare and submit to this committee a written statement supplementing his formal report. We have further asked that he very briefly give you his opinion concerning the remedial work which may be required to alleviate the district's problem together with what can only be a very rough estimate of cost.

Needless to say, we appreciate the current efforts being made by the Interior Department, both through the United States Geological Survey and the Bureau of Reclamation, to survey the entire problem and make recommendations. I am sure that you may depend upon our full cooperation in resolving the existing problem not only for the direct benefit of our own district but for the benefit of the general area as well.

In view of my inability to answer rather technical questions, I would like to present Mr. John R. Iakisch.

Senator ANDERSON. I am happy to have him here, but let me ask you this: What relationship does this have to the controversy that apparently exists between the Yuma Mesa and the Yuma Valley? Is it a new quarrel?

Mr. BRADLEY. It is a confounding bit of water rising in the same area, sir.

Senator ANDERSON. Well, the map shows the area that is the Yuma Mesa area.

Mr. BRADLEY. Yes.

Senator ANDERSON. And then it shows the Yuma Valley, the valley division. Now you lie to the north of that?

Mr. BRADLEY. Yes.

Senator ANDERSON. Is it your contention that the same water that is troubling the valley people is also coming from Yuma Basin?

Mr. BRADLEY. That, I think, is established in Mr. Iakisch's report.

Senator ANDERSON. Is he here?

Mr. BRADLEY. Yes, sir; he is. May I turn this difficult spot over to him?

Senator ANDERSON. It isn't that difficult, but come on up, Mr. Iakisch.

Senator ANDERSON. Your name is Mr. John R. Iakisch?

STATEMENT OF JOHN R. IAKISCH, YUMA IRRIGATION DISTRICT

Mr. IAKISCH. Yes, sir.

Senator ANDERSON. Did you prepare the report on drainage conditions in the South Gila Valley District dated February 1956?

Mr. IAKISCH. Yes.

Senator ANDERSON. As consulting engineer?

Mr. IAKISCH. Yes.

Senator ANDERSON. Is it your contention that the water from the Yuma Mesa flows northward into this area, or whatever direction it is?

Mr. IAKISCH. Yes.

Senator ANDERSON. It flows that direction?

Mr. IAKISCH. Yes.

Senator ANDERSON. It couldn't flow both south and north at the same time, could it?

Mr. IAKISCH. Oh, yes.

Senator ANDERSON. It could?

Mr. IAKISCH. The source, of course——

Senator ANDERSON. Generally speaking, water does not run uphill.

Mr. IAKISCH. No.

Senator ANDERSON. I don't know how you do here.

Mr. IAKISCH. The high point of ground water on the mesa is somewhat to the east of the pumping plant of the old area up there, and from that high peak of the ground water the slope is in all directions, north, east, south, and west, and naturally the ground water flows in the direction of the slope.

Senator ANDERSON. The mesa isn't that much higher, is it, toward your land?

Mr. IAKISCH. Yes.

Senator ANDERSON. How much is it above your land?

Mr. IAKISCH. Seventy-five to a hundred feet.

Senator ANDERSON. The break didn't look to be that much, but it may be.

Mr. IAKISCH. Yes. It increases in height.

Senator ANDERSON. Then what I am trying to get at is the remedy proposed by the valley division is not in any way applicable or effective as to your area?

Mr. IAKISCH. It is not effective. The same procedure might be used, but it is a different problem. We are pestered with the water that is coming from the mesa to the north, flowing from the mesa to the north. I understand the valley division claims that its problem is the water that is coming from the mesa to the west. Both could happen; both undoubtedly do happen.

Senator ANDERSON. It is your contention, then, that a similar type of treatment should be given for the Yuma Irrigation District as has been proposed for the Yuma Valley Water District; or is that right? What treatment do you suggest for your problem?

Mr. IAKISCH. We are at present making investigations in the area, for which funds were provided by Congress to the Bureau of Reclamation, and on the basis of those investigations, the Bureau of Reclamation is to make a drainage plan and an estimate of cost. When those investigations are completed, why, then that estimate will be made available. Now, of course, I have my own ideas.

Senator ANDERSON. Would you mind letting us know what your ideas are?

Mr. IAKISCH. I believe they will be very similar to what the Bureau of Reclamation will come out with after it has made its investigations, but we just got into this picture just within the last months, within the last year. We have had no examination of our area.

As Mr. Bradley indicated, we found that the water table was rising on us. All the way up into the middle forties, it has been static. We found that it had been rising on us, and in late years it has got to the point where we are beginning to be alarmed as to its final effect upon crop production and land itself. Therefore, we have asked for these investigations, and I think the investigations to some extent were made because of the condition that I indicated in my report.

Senator ANDERSON. Now as we flew in this morning, we came over the Wellton-Mohawk area. I had heard a good deal about that before we came over this morning. Senator Hayden wanted cotton quotas increased a little bit in that area. Is the slope from the Wellton-Mohawk section to your area?

Mr. IAKISCH. Yes.

Senator ANDERSON. Is it possible that the Wellton-Mohawk may be dumping water on you?

Mr. IAKISCH. Entirely possible.

Senator HAYDEN. For that reason, Mr. Chairman, I might state that Mr. Dexheimer, Commissioner of the Bureau of Reclamation, asked, if I remember correctly, for $35,000 to look into this entire drainage and seepage problem. Obviously it covers the whole area, and that study will have to be made of the whole area. If the situation is such that it requires the cutting of a channel, for example, up the Gila to get the water quickly into the Colorado River, that may be one solution. We don't know what it will be, but I do know that Mr. Dexheimer has some funds, and he may need more. If he does, I am going to try to get them for him, to get a thorough engineering study of all the problems in all the area.

Mr. Chairman, I think that we are here today to consider the particular problem that has arisen between the Yuma Valley and the Yuma Mesa with respect to that area.

Senator ANDERSON. That is what I wanted to get to. We have had this problem of the Yuma Mesa and the Yuma Valley before us. I don't want to get diverted off on a problem of what causes trouble in the Yuma Irrigation District and in the Wellton-Mohawk if we can help it, because the time is limited. If we should be studying the whole thing, then, of course, it is true that we should go on with these others before we get through with it. I realize that you may have a

problem and it may be caused by someone else who also is in trouble because of somebody else. We don't know exactly where these things end. I would like to know for the purpose of this hearing whether you are in position to testify that there is a relationship between the Yuma Mesa District and your area?

Mr. IAKISCH. It's part of the problem; it's not the whole problem. The South Gila District lies in and is probably the lowest portion of the surrounding areas, all of which are irrigated. It is lower than the mesa, it is lower than the Mohawk, it is lower than the North Gila, and in every one of those places the ground water is higher than it is on the South Gila Valley. Naturally, as you know, ground water flows in the direction of the greatest slope. All right. There is only one place it heads for: The South Gila Valley.

Senator ANDERSON. What I am trying to find out is if we have more of a problem than just a problem between the mesa and the valley district.

Mr. IAKISCH. Yes.

Senator ANDERSON. A solution of that should include, then, as you say, the Yuma Irrigation District because you are still lower?

Mr. IAKISCH. Should include, yes, all the property, all the contiguous areas, which does not include the valley division.

Senator ANDERSON. Do you have any questions, Senator Hayden?

Senator HAYDEN. No questions.

Senator ANDERSON. Do you have any questions, Congressman Udall?

Congressman UDALL. Yes. Your problem is not as critical at the moment as the problem of the valley?

Mr. IAKISCH. We feel that there is immediate danger of something happening. We can't claim at the present time that we have very much land out of cultivation because of the high-water table.

Senator ANDERSON. Are you pumping?

Mr. IAKISCH. Yes. We get all of our water from pumping; practically all of it.

Senator ANDERSON. Are you pumping to get rid of the surface water?

Mr. IAKISCH. No; we are pumping to get irrigation water.

Senator ANDERSON. That is a little different problem.

Mr. IAKISCH. But it is affected as far as drainage is concerned.

I wish to make a statement here that, as Mr. Bradley indicated, the South Gila District imported no foreign water for irrigation purposes whatsoever up to 1946. It obtained all its irrigation water by pumping from the underground on the project itself. Each landowner has his own separate pump, or 1 or 2 pumps, to obtain his irrigation water.

Now under those circumstances, all that the district could possibly put back into the ground water is the difference between what it pumped out and the consumptive use, which is less.

Senator ANDERSON. In other words, due to the increased pumping by the district, there was no rise in the water table up to 1946?

Mr. IAKISCH. There is no question about that.

Senator ANDERSON. What is it doing now? What is the situation now?

Mr. IAKISCH. In 1946 we got a little water out of the Mohawk Canal and a little bit out of the Colorado River, but this amount of water that goes into the ground-water reservoir under the district from

the imported water from the outside is very much smaller than the consumptive use of what we pump out of the ground, and even under these conditions there is no possibility of the district adding to the ground water by its operations. There is a slight accretion to the ground water from the Gila Canal. For that reason, it is not foreign water that is imported, because that is very small. Only 7.7 percent of the acreage receives imported water.

Senator ANDERSON. You have how many acres? 12,000?

Mr. BRADLEY. Yes.

Senator ANDERSON. How many acre-feet do you import?

Mr. IAKISCH. You see, I don't believe anybody in the district could tell you because those people are not in the district.

Mr. BRADLEY. Sir, what was your question?

Senator ANDERSON. The question is, How many acre-feet do you import? He said you once originally got all your water by wells.

Mr. BRADLEY. There are 885 acres that import 8 acre-feet per acre of the 12,000 acres, which makes in the neighborhood of——

Senator ANDERSON. Is that all of the imported water?

Mr. BRADLEY. Yes, sir; for the South Gila Valley, that is all.

Senator ANDERSON. I can't follow you with the South Gila Valley and the Yuma Irrigation District.

Mr. BRADLEY. It is the Yuma Irrigation District—within the boundaries of the Yuma Irrigation District.

Senator ANDERSON. This is all the water you import within the boundaries of the Yuma Irrigation District?

Mr. BRADLEY. Yes. And that would be slightly misleading, because in an area which is not exactly within our district, but next to the Colorado River, there is some pumping on 320 acres from the river.

Senator ANDERSON. But that is minor?

Mr. BRADLEY. Right; yes.

Senator ANDERSON. Now then, since you are not importing any water, Mr. Iakisch, your grand-water level is rising?

Mr. IAKISCH. Yes.

Senator ANDERSON. Seriously?

Mr. IAKISCH. Very seriously.

Senator ANDERSON. Thank you.

Congressman UDALL. Let me ask you this hypothetical question. If the Wellton-Mohawk development had not taken place, if the Yuma-Mesa development had not taken place, do you still feel that this irrigation district would be faced with a rising water table?

Mr. IAKISCH. Why, no.

Congressman UDALL. You don't?

Mr. IAKISCH. No.

Congressman UDALL. So you attribute the rise to one or the other causes and these other factors that you mentioned?

Mr. IAKISCH. Let me put it this way: That I attribute the rise of the ground-water table in the South Gila district to the operation of those divisions and those projects, contiguous divisions and projects, for which irrigation systems were constructed by the Bureau of Reclamation.

Congressman UDALL. That is the fact that I wanted to bring out.

Mr. IAKISCH. Yes.

Congressman UDALL. That's all.

Senator HAYDEN. Mr. Chairman.

Senator ANDERSON. Senator Hayden.

Senator HAYDEN. For reason that the Bureau of Reclamation has constructed more water projects around here—that was why the Congress appropriated money—it was $60,000 made available for this year and $114,000 for 2 years.

Now, that study covers everything, particularly this South Gila area and the Mohawk and the drainage between the confluence of the Gila and the Colorado River, and that will all produce very interesting data. But that has yet to be dug up.

My understanding of today's hearing, the purpose that we are here in this limited time, is to try to determine whether the water from the Yuma Mesa, as applied to the Yuma Mesa, is actually causing the rise in the water table in the Yuma Valley. Now I think if we confine ourselves to that, why, we will be able to conclude this hearing during the course of the day. When Mr. Dexheimer and his experts get through with the expenditure of the money that was provided for them, they will undoubtedly have a great deal of very interesting data that the Congress would have to consider.

Mr. BRADLEY. Mr. Chairman.

Senator ANDERSON. Yes.

Mr. BRADLEY. I wanted to clear for the record that we had been invited, whether properly or not, to give our testimony at this meeting by Mr. Eaton and Mr.——

Senator ANDERSON. I want to say this to you. We try, whenever we go anywhere, to clear up all the trouble spots we can get to. But when it comes to the real discussion and purpose of this meeting, we will be glad to have your testimony and consider that, but for the purpose of this meeting, we are going to try to stay on the Yuma Mesa and the Valley division.

Mr. BRADLEY. Very good, sir.

Senator ANDERSON. Thank you, then, Mr. Iakisch.

Mr. Lineweaver, will you have placed in the record a copy of the Colorado River Front and Levee System Act of June 28, 1946, which I believe forms the authority for the Department of the Interior, through the Bureau of Reclamation or independent consultants, to make investigations and to construct, improve, extend, operate, and maintain protection and drainage works and systems along the Colorado River?

(The material referred to is as follows:)

COLORADO RIVER FRONT WORK AND LEVEE SYSTEM ACT, ACT OF JUNE 28, 1946

AN ACT To amend the laws authorizing the performance of necessary protection work between the Yuma project and Boulder Dam by the Bureau of Reclamation (60 Stat. ——, ch. 517)

That the provision of the Act entitled "An Act authorizing the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved January 21, 1927 (44 Stat. 1010, 1021), amended by the Act entitled "An Act to authorize defraying cost of necessary work between the Yuma project and Boulder Dam," approved July 1, 1940 (54 Stat. 708), is hereby further amended to read as follows:

"That for the purpose of controlling the floods, improving navigation, and regulating the flow of the Colorado River, there is hereby authorized to be appropriated, out of any moneys in the Treasury of the United States not otherwise appropriated, for the fiscal year ending June 30, 1928, and annually thereafter, such sums as may be necessary, to be spent by the Bureau of Reclamation under the direction of the Secretary of the Interior, to defray the

cost of (a) operating and maintaining the Colorado River front work and levee system in Arizona, Nevada, and California; (b) constructing, improving, extending, operating, and maintaining protection and drainage works and systems along the Colorado River; (c) controlling said river, and improving, modifying, straightening, and rectifying the channel thereof; and (d) conducting investigations and studies in connection therewith: *Provided*, That the expenditure of moneys for any of the foregoing purposes shall not be deemed a recognition of any obligation or liability whatsoever on the part of the United States: *Provided further*, That, within the discretion of the Secretary of the Interior, local communities to be benefited by works constructed pursuant to this Act may be required to provide, without cost to the United States, necessary rights-of-way and maintenance of the completed works and assurance, satisfactory to him, of payment of valid claims arising out of damage caused to persons or property by reason of the construction, operation, or maintenance of any such works: *Provided further*, That any moneys received by the United States as reimbursement in accordancce with contracts heretofore entered into under the authority of the Act of December 21, 1928 (45 Stat. 1057), as amended, and ratified by the Act of August 30, 1935 (49 Stat. 1028, 1039), for expenditures made under the authority of this paragraph, shall be covered into the Treasury as miscellaneous receipts. In connection with operations conducted under this paragraph, the Secretary of the Interior shall have the same authority with respect to (a) the acquisition, exchange and disposition of lands, interests in lands, water rights and other property, and the relocation thereof; (b) the utilization of lands owned or acquired by the United States; (c) construction and supply contracts; (d) the performance of necessary or proper acts; and (e) the making of necessary or proper rules and regulations, which he has in connection with projects under the Federal reclamation laws, Act of June 17, 1902 (32 Stat. 388), and Acts amendatory thereof or supplementary thereto. Nothing contained in this paragraph shall be deemed to amend, repeal, or otherwise affect the provisions contained in the First Deficiency Appropriation Act, 1944, under the caption 'Department of the Interior, Bureau of Reclamation—Colorado River front work and levee system' (58 Stat. 150, 157)."

Legislative history—H. R. 5674, Public Law 469, 79th Congress; House Report 1818; Senate Report 1474; 92 Congressional Record 6094; 6830; 7048; House hearings before committee on Rivers and Harbors, March 19, 1946.

Senator ANDERSON. I think we will go on with the next witness. Yuma-Mesa Irrigation District, Mr. Everett Miller.

Will you please identify yourself.

STATEMENT OF EVERETT L. MILLER, COUNSEL, YUMA-MESA IRRIGATION AND DRAINAGE DISTRICT

Mr. MILLER. My name is Everett L. Miller. I am the attorney for the Yuma-Mesa Irrigation and Drainage District.

I am going to limit my remarks only to the filing of a very short statement, with your permission, Mr. Chairman.

Senator ANDERSON. Read that, if that is what your statement is.

Mr. MILLER. This is a statement signed by John R. Scarbrough, president of the Yuma-Mesa Irrigation and Drainage District:

My name is John R. Scarbrough and I am president of the board of directors of the Yuma-Mesa Irrigation and Drainage District of Yuma, Ariz.

I wish to welcome the chairman and all others traveling to Yuma for this hearing.

It is my understanding that this hearing was called in order to allow interested parties to make comment on the report of the United States Geological Survey entitled "Analysis of Basic Data Concerning Ground Water in the Yuma Area, Arizona," issued April 20, 1956, and for no other purpose.

The Geological Survey report was made pursuant to a recommendation by this committee in a report of July 21, 1955, on S. 1689.

The irrigation district I represent does not operate the distribution works which serve the district lands. Those works are operated and maintained by

the Bureau of Reclamation. For that reason, the district does not employ an engineer of any kind and has no persons on its payroll qualified to study and comment on the Geological Survey report. For that reason, the Yuma-Mesa Irrigation and Drainage District has no comments on the report.

I do wish to favorably comment on the action of the Congress through the Senate Appropriation Committee report on the fiscal year 1957 appropriation bill which earmarked $60,000 of nonreimbursable Colorado River front and levee system funds for study of drainage problems in the entire Yuma area. The Bureau of Reclamation has held conferences with all of the six Yuma irrigation districts and has worked out a plan for such further study. The Bureau of Reclamation employs highly competent engineers and their work is valuable.

In addition to this work, each of the six local districts are spending large additional sums to further study and correct their drainage problems.

Thank you very much.

The statement is signed by Mr. John R. Scarbrough.

Senator ANDERSON. Senator Hayden, do you have any questions?

Senator HAYDEN. No.

Senator ANDERSON. Congressman Udall?

Congressman UDALL. I just wanted him to elaborate one point. In other words, as far as the planning of the Yuma-Mesa irrigation district and its works, the governing board of that irrigation district had nothing to do with it and has nothing to do with its operation today?

Mr. MILLER. That's correct.

Congressman UDALL. In other words, it is planned by the Bureau of Reclamation and your organization only came into being when it was necessary to set up an irrigation district to take over and operate the project?

Mr. MILLER. That's right.

Congressman UDALL. That is all I have.

Senator ANDERSON. Thank you, sir. Mr. Jacob will be heard next. Will you please identify yourself?

STATEMENT OF CHARLES E. JACOB, CONSULTING ENGINEER, OREM, UTAH

Mr. JACOB. My name is C. E. Jacob, consulting engineer, Orem, Utah. On this project I am associated with the engineering firm of Tipton & Kalmbach, Inc., of Denver, Colo.

I have been asked by the Secretary of the Interior to review reports and unpublished data on the problem which is the item of consideration of this committee at the present time. I might introduce myself.

I am a graduate of the University of Utah with a degree of civil engineering in 1935; of Columbia University with a degree of hydraulic engineering in 1936; I have been a graduate student in Columbia University in physics and hydraulic engineering, in George Washington University, and at the University of Utah in geology. For 5 years I was head of the geophysics department of the University of Utah, and for 1 year professor of geology at Brigham Young University. Prior to that time I served for 11 years with the groundwater division of the United States Geological Survey.

Since 1947 I have been in consulting practice part time, and since 1951 full time. This practice has taken me to several foreign countries, including Formosa, Israel, Latin America, and Canada. My

specialty is underground water. I would like to begin, if I may, by pointing out some obvious errors in the report. There are only a few. I think it is only fair to those who have just received the report today, as I did. If you will turn to page iii of the prefatory material to the report, in the third paragraph on the second line it reads "* * * not more than about 1.4 million acre-feet * * *." That "1.4" should be "0.8." Will you please correct your copy accordingly?

In the following paragraph, the fourth paragraph of that page, insert before the word "40", before the numeral "40", the words "more than."

On page iv, the top line, before the numeral "100" will you kindly insert "probably not more than," so that it reads, "* * * probably not more than 100,000 acre-feet * * *."

And on the second line, please insert before the numeral "124", the word "about". And on the third line before the number "36", the words, "not less than", so that it reads, "* * * and not less than 36,000 acre-feet * * *."

Senator ANDERSON. Have you any idea how much more than 36,000 feet it is?

Mr. JACOB. Senator, our conclusion is that it is not less than that.

Senator ANDERSON. Is it more than that?

Mr. JACOB. Yes. In reading the synopsis, I will point out an upper limit which has been set. We have set a lower limit and also a probable upper limit on these figures.

Will that suffice if I read that later?

Senator ANDERSON. Yes.

Mr. JACOB. Thank you very much for calling my attention to that.

Now, there is only one other correction, which is on page 56, in the second paragraph, the ninth line from the top. Again it says, "1.4 million acre-feet * * *". That obviously should be "0.8 million acre-feet," as one can see that it is just a slip of the tongue. The arithmetic shows that it is 0.8 by the figures that are given above and below.

If anyone else finds any errors, and I am sure they may be found, will you kindly notify the author, because we would like to correct the errors.

I have given my qualifications. I know that the firm of Tipton & Kalmbach, and especially Mr. R. J. Tipton, the senior partner of that firm, is well known to administrators of water resources in Arizona, in Mexico and Colorado, indeed all over the world, and so I shall not elaborate upon Mr. Tipton's qualifications. He asked me to represent his firm as well as myself in this collaborative effort.

I would like to begin by reading just very briefly from our introduction.

This report is made to the Secretary of Interior in response to a request by Mr. Fred G. Aandahl, Acting Secretary. The report is the result of collaboration between the firm of Tipton & Kalmbach, Inc., of Denver, Colo., known as the consulting organization, and C. E. Jacob of Orem, Utah, known as the consultant. The reason for the investigation and the terms of reference were outlined by Mr. Aandahl in letters to the consulting organization and to the consultant, September 18, 1956, as follows—

I am quoting now from Mr. Aandahl's letter.

"Whereas the Bureau of Reclamation and the Geological Survey have made extensive investigations and studies of the water table underlying portions of the lands of the Valley Division of the Yuma Federal reclamation project (here-

inafter referred to as the Valley Division) and have gathered substantial data concerning the same; and

"Whereas the Department of the Interior is concerned with the effect of such water table upon the continued irrigation of the lands of the valley division, has considered the investigation thereof made by the above agencies and now desires to have independent engineering consultants review the existing investigative data and to study the cause or causes of ground-water conditions, and to submit a report thereon with appropriate recommendations;

"Now, therefore, the parties hereto do covenant and agree as follows:

"The consulting organization, in collaboration with another consultant to be designated by the contracting officer"—

I am that other consultant—

"shall make a review of all presently available data pertinent to the relationship, if any, of irrigation of the Yuma Mesa division (Gila project) to the levels of the water table underlying the valley division (Yuma project). It shall, in collaboration with such other consultant, report to the contracting officer upon the location of any areas in the valley division found to be affected by high-water table and/or seepage; the cause or causes of such high-water table and/or seepage; the relationship between and relative importance of such causes; suggested remedial action and construction; estimated cost of remedial action and construction; and comment on the adequacy of available information to serve as a basis for determining the full answer to the problem, and if additional information is needed, its nature and the cost of obtaining it."

Now I think I can do no better, Senator Anderson, than to read the synopsis of the report. However, I shall interject at appropriate places a little amplification where it seems necessary. I am reading now from page i of the written report. Much of this material is historical, and I think in the interest of time I shall skip that on the first two pages, because it has already been covered by others who testified before me.

Senator ANDERSON. What you are going to read, does that give the answers to these questions asked?

Mr. JACOBS. Yes; we believe the answers are given. If the complete answer is not found in the synopsis, it will be found there and in the conclusions at the back of the report.

Senator ANDERSON. At this point will be printed the synopsis, pages i–x, of your report.

SYNOPSIS

The Yuma project, one of the oldest Federal reclamation projects in the United States, was authorized shortly after the passage of the Reclamation Act in 1902. The project, with a gross area of 50,000 acres and a net irrigated area of some 47,000 acres, lies between Yuma on the north and the Mexican boundary on the south, and between the Colorado River on the west and the Yuma Mesa on the east. The average elevation of the project area is about 100 feet above sea level.

The project was served by a canal diverting from Laguna Dam on the Colorado River until the All-American Canal went into operation. Since that time it has been served by a diversion from the All-American Canal which delivers water to what is known as the siphon drop.

Because the area has no surface outlet and because of its relatively low elevation in respect to the Colorado River on the west and to the Gila River, drainage became a problem early in the history of the project. By 1916 the first drains were constructed and shortly thereafter the drain water was being pumped into Mexico at the lower boundary near the town of San Luis, Sonora. The construction of the drainage system continued to keep pace with the rising water table as the development of the irrigated lands proceeded. In 1921 main drain lines extended the entire length of the valley.

In 1917 the Yuma Mesa auxiliary project was authorized for construction on the edge of the Yuma Mesa at an elevation some 90 feet above the valley division. This unit was served by a pumping plant from 1922 until 1953. After

the Yuma Mesa auxiliary project went into operation the Yuma County Water Users Association, which is in control of the Yuma project, feared that the irrigation of the auxiliary project would increase the drainage problems in the valley immediately below the auxiliary project. The Bureau of Reclamation in cooperation with the association installed 9 pump wells to a depth of about 100 feet to supplement the drainage system of the project.

In 1946 the Yuma Mesa division of the Gila project went into operation. This division of the Gila project is served by a canal which heads in the Imperial Dam, siphons under the Gila River, and extends to the foot of the Mesa where the water is pumped up to the canal system serving the mesa lands, which includes the Yuma Mesa auxiliary project. At the present time 14,500 acres are irrigated in the Yuma Mesa division of the Gila project in addition to the area within the auxiliary project.

Soon after the irrigation of the Yuma Mesa division of the Gila project commenced the Yuma County Water Users Association again became concerned because of anticipated worsening of seepage conditions within the valley. The association immediately began deepening and improving the drainage system of the project. As a part of the program six drainage wells along the eastern edge of the project near the toe of the mesa were constructed. These wells extend to a deep aquifer some 200 feet below the surface and 100 feet below sea level. The aquifer consists of coarse gravel. Apparently most of the ground water being transported westward and southwestward from the Gila area proper and from the Mesa is through this aquifer. The wells have a relatively large capacity, averaging some 10 cubic feet per second. The construction of others is contemplated. The shallow Bureau of Reclamation wells are being abandoned.

Since the Yuma Mesa division of the Gila project went into operation in 1946 some 2.2 million acre-feet of water have been imported to the mesa area. This has resulted in a rapidly rising water table in the area which late in 1955 necessitated the construction of the first drain on the mesa. This drainage system, however, serves only a small area 500 acres in extent.

It is estimated that by 1955 of the 2.2 million acre-feet imported to irrigated lands on the mesa not more than about 1.4 million acre-feet were used consumptively; about 1.0 million acre-feet went into storage under the mesa; and not less than about 0.4 million acre-feet flowed out from the mesa to the South Gila Valley and the Yuma Valley. This outflow commenced in 1945 and has been increasing each year until the last 2 or 3 years.

For the last 8 years it is estimated that the outflow from the mesa has averaged 40,000 acre-feet per year, 11,000 acre-feet to the South Gila Valley, and 29,000 acre-feet to the Yuma Valley.

An approximate inventory of the 260,000 acre-feet of water imported on the average each year to Yuma Mesa during the period 1953–55 discloses that 100,000 acre-feet per year were used consumptively by the crops, 124,000 acre-feet went into storage causing the rising of the water table, and 36,000 acre-feet passed the boundaries of the mesa, 11,000 acre-feet to South Gila Valley, and 25,000 acre-feet to Yuma Valley.

In respect to the Yuma Valley for the year 1955 it is estimated that 280,000 acre-feet was imported, of which 164,000 acre-feet is estimated to have been consumptively used, leaving a return of 116,000 acre-feet. During that year 106,000 acre-feet of subsurface and surface drainage was pumped at the Mexican boundary, leaving 10,000 acre-feet. During the same year drainage wells and sumps pumped a total of about 31,000 acre-feet of which about 2,000 acre-feet was pumped into the drainage system, the remaining 29,000 acre-feet being pumped into the canal system.

The amount pumped during the year 1955 from wells and sumps is in excess of the estimated importations underground from the mesa for that year. However over the past 8 years it is estimated that the average inflow from the Yuma Mesa to the Yuma Valley underground averaged 29,000 acre-feet per year, while the pumpage from the drain wells and sumps averaged only about 17,000 acre-feet per year.

Although apparently the corrective measures progressively effected by the Yuma County Water Users Association have not kept pace fully with the increased importation to the valley from the mesa, nevertheless it is concluded that there has been very little, if any, damage to the valley lands up to this time because of the irrigation of the lands on the mesa. This in part is because of a change of regimen of the flow of the Colorado River and its channel, which has been of some benefit to the valley. Since Hoover Dam went into operation few

sustained flood flows have passed the project and during the last few years the channel has degraded. During recent years also the total flow in the Colorado River passing the project has been much less than formerly. This has had the effect of lowering the water table along the western portion of the project. It is probable that this has resulted in the discharge of a greater quantity of groundwater from the east to the west and southwest into Mexico.

It is concluded, however, that unless the addition of drainage facilities keeps pace with increased importations from the mesa area, material damage will result to a portion of the valfflley lands, particularly those lying on the eastern edge under the mesa. Those lands which would be damaged first and damaged the most severely would be those lying in what is known as the Big Bend area.

It is concluded that importations by subsurface interflow from the mesa to the valley will progressively increase. For the period 1953–55 it has already been shown that of the 260,000 acre-feet per year of water imported to the mesa it is estimated that 124,000 acre-feet per year went into storage. If the large importations, which at the present time average about 15 acre-feet per acre of lands irrigated continue, the ground-water reservoir lying under the mesa inevitably will fill, which will cause the seepage of lands on the mesa and will eventually require the drainage of those lands.

If the surface-water importations to the mesa remain high, the water which now is going into storage must find its way to adjacent low-lying areas including the South Gila project, the Gila Valley project, and Mexico. Probably more than 150,000 acre-feet of water per annum will be involved in this movement. If the irrigated area on the mesa is extended with further importations at the same rate in acre-feet per acre as the present importation, the quantity of water to be disposed of by ground-water movement each year will be increased still further.

It is apparent that the problem cannot be confined to a limited area. It has a regional aspect. The hydrological region now involved and to be involved to a greater extent in the future includes the Wellton-Mohawk area to the East, the South Gila area, the Yuma Mesa, the Yuma Valley, and Mexico on the South and the West. Most of this region is underlain by a highly transmissive coarse-gravel aquifer, the top of which is at about sea level. It is believed this aquifer is a controlling factor in the underground hydrology of the region.

A comparison of the results of quality of water analyses of Colorado River water. Gila surface water, and Gila ground water with the results of quality of water analyses of the deep wells in the Yuma Valley indicates that under much of the Yuma Valley the flow in the deep gravel aquifer generally comes from the Gila River Basin. A comparison indicates that the Colorado River may be supplying some water to the acquifer across the north and west portions of the valley. Most of the wells along the east side indicate a mixing of Gila and Colorado River water, the latter probably coming from importations to the surface of the mesa.

The hydrologic regimen of the whole area will be affected if increasing amounts of water are imported to the Wellton-Mohawk and Yuma Mesa areas. The regimen also is being influenced by seepage from the All-American Canal, the Mexican system of canals diverting from the Morales diversion structure, and the water being applied to a portion of the Mexicali Valley, in Mexico. The regimen may also be affected by pumpage of water from wells in Mexico west of the Colorado River.

It is believed that the ultimate hydrologic balance of the region must be considered. The most important regional aspect of the entire problem obviously is the control and disposal of the returns of large amounts of water that are now being imported and the additional amounts that will be imported to the projects located in the region.

Time did not permit an adequate appraisal of means for coping with the problem in the valley unit of the Yuma project. One approach would be to anticipate the deleterious effect of rising water table in certain areas by means of observation wells in sufficient time to better the drainage facilities for those areas by the construction of tile drains or the installation of additional deep pump wells.

Another approach would be by means of additional field studies, to attempt to predict what the ultimate overall picture might be, and to embark upon a full-scale expansion of drainage facilities in the near future to obviate adverse effects to the low irrigated lands situated adjacent to the mesa because of increased importations from the mesa.

If the latter course is the one adopted, it is believed tentatively that for the valley the most economical and effective program would be to deepen materially

the main drainage channel and, to the extent necessary, the lateral drains, and to install additional deep pump wells at the foot of the mesa.

Another main drain running across the valley from east to west to relieve the burden on the present drainage system may be indicated. The water would be pumped from the transverse drain into the Colorado River.

Considering the entire region, it is believed also that a deep drainage channel should be constructed along the Gila River from the Narrows near Dome to the Colorado River. This channel would provide some protection to the Yuma Valley and to the South Gila project, and it would provide an outlet for any drains that might be indicated as necessary for the latter project.

The following investigational program should be carried out:

1. Improve accuracy of surface waterflow measurements and accounting, particularly in respect to the measurement of water deliveries and return.
2. Construct twenty-four 4-inch-diameter observation wells of 200-foot depth on the Yuma Mesa.
3. Construct eighty 2-inch-diameter shallow water-table observation wells on the Yuma Mesa.
4. Install six automatic stage recorders on selected wells.
5. Run seismic refraction profiles at the narrows below Dome, at the location of the Gila Canal siphon, and along the mesa in line with the rock outcrops. Further seismic exploration may be indicated as the result of the above.
6. Make pumping tests (step-drawdown and recovery tests) on all operating pump wells on the mesa, in the valley, and in the South Gila project.
7. Observe the water level in all observation wells at not less than monthly or bimonthly intervals.
8. Take samples and make qualitative analyses of the water from representative wells and surface supplies at selected locations.
9. Make final analysis of a 2-year investigation involving the above and from final analysis make an estimate of the ultimate movement of the ground water as storage builds up under the mesa, and conceive the outline of remedial measures which ultimately should be consummated to prevent lands adjacent to the mesa from being adversely affected by irrigation on the mesa.

The reading of the observation wells to determine water levels, the sampling of ground water and surface water at selected points to determine quality, and the maintenance of the water stage recorders on the selected wells should be a continuing program.

It is estimated that the 2-year program outlined above would cost approximately $90,000, of which $35,000 would be for capital investment. The balance would be for services and expenses of personnel not already engaged on project operations nor incident to ordinary governmental activities in the area.

Neither information nor time permitted the estimation of the cost of those works and facilities required to prevent damage to valley lands because of increased importations from the mesa. The cost of works ultimately required will run into the hundreds of thousands of dollars.

Mr. JACOB. Beginning with the second paragraph of page 11, then:

In 1946, the Yuma Mesa division of the Gila project went into operation. This division of the Gila project is served by a canal——

Senator ANDERSON. Let me just stop you and ask you a question. We know the history.

Mr. JACOB. I am skipping that.

Senator ANDERSON. What are the answers?

Mr. JACOB. I purposely skipped the history to bring us down to 1946, because we believe there is where the answer is needed to be sought first, that is, in our understanding, and this now gives the answers to the questions.

Senator ANDERSON. All right, go ahead.

Mr. JACOB (reading):

This division of the Gila project is served by a canal which heads into the Imperial Dam, siphons under the Gila River and extends to the foot of the Mesa where the water is pumped up to the canal system serving the mesa lands, which includes the Yuma Mesa auxiliary project. At the present time, 14,500 acres are irrigated in the Yuma Mesa division of the Gila project in addition to the area within the auxiliary project.

Incidentally, that is about 2,500 acres, a total roughly of 17,000.

Soon after the irrigation of the Yuma Mesa division of the Gila project commenced, the Yuma County Water Users Association again became concerned because of anticipated worsening of seepage conditions within the valley. The association immediately began deepening and improving the drainage system of the project. As a part of the program, six drainage wells along the eastern edge of the project near the toe of the mesa were constructed. These wells extend to a deep aquifer some 200 feet below the surface and 100 feet below sea level. The aquifer consists of coarse gravel. Apparently most of the ground water being transported westward and southwestward from the Gila area proper and from the mesa is through this aquifer.

And I would like to interject here, by referring for your later reading to page 24, that according to our calculation, before there was any appreciable irrigation upon the mesa, that is, in 1925, as shown by maps in the survey report and our interpretation of those maps, the natural groundwater flow in a south-southwestward direction under the mesa and under the valley amounted to about 15,000 acre-feet per year. This is taking in the width of the valley 20 miles eastward from the Colorado River. How much flowed in that direction on the other side of the river, we did not attempt to estimate.

Now about these wells that tap this deep aquifer:

The wells have a relatively large capacity, averaging some 10 cubic feet per second. The construction of others is contemplated. The shallow Bureau of Reclamation wells are being abandoned.

Since the Yuma Mesa Division of the Gila project went into operation in 1946, some 2.2 million acre-feet of water have been imported to the mesa area. This has resulted in a rapidly rising water table in the area which late in 1955 necessitated the construction of the first drain on the mesa. This drainage system, however, serves only a small area 500 acres in extent.

It is estimated that by 1955 of the 2.2 million acres-feet imported to irrigated lands on the mesa, not more than about 0.8 million acre-feet—

or 800,000 if you please—

were used consumptively; about 1 million acre-feet went into storage under the mesa; and not less than about 0.4 million acre-feet flowed out from the mesa to the South Gila Valley and the Yuma Valley. This outflow commenced in 1945 and has been increasing each year until the last 2 or 3 years.

For the last 8 years—

up until December 1955—

it is estimated that the outflow from the mesa has averaged more than 40,000 acre-feet per year, 11,000 acre-feet to the South Gila Valley, and 29,000 acre-feet to the Yuma Valley.

An approximate inventory of the 260,000 acre-feet of water imported on the average each year to the Yuma Mesa during the period 1953–55—

that means December 1953 to December 1955—

discloses that probably not more than 100,000 acre-feet per year were used consumptively by the crops, about 124,000 acre-feet went into storage, causing the rising of the water table, and not less than 36,000 acre-feet passed the boundaries of the Mesa, 11,000 acre-feet to the South Gila Valley, and 25,000 acre-feet to Yuma Valley.

Senator ANDERSON. Not being an engineer, I am probably asking a very stupid question, but why wouldn't one way of remedying this situation be to see that you didn't take in more water than you thought you were going to use?

Mr. JACOB. Well, Senator Anderson, I don't know if that is a full solution; it might be a partial solution. There is always——

Senator ANDERSON. I didn't say it was a full solution.

Mr. JACOB. Partial.

Senator ANDERSON. If a man starts putting on weight because he is eating 2 potatoes and a slice of bread, 1 of the ways to cut down is to eat 1 potato.

Mr. JACOB. Agreed.

Senator ANDERSON. But if you are getting in 260,000 feet, using 100,000 feet, why don't you limit the intake to what you are going to use?

Mr. JACOB. That is a question?

Senator ANDERSON. That is my question.

Mr. JACOB. My answer is that undoubtedly this is a partial answer. Another answer is that, of course, you will always have returns from irrigation, and since the mesa presently has no surface outflow, not even for the water which they pump from their drains, then you are going to have to realize that there is going to be more subsurface return, more subsurface outflow than ordinarily would be the case. So this project is a little different in that respect. It has no surface drainage, unless I am mistaken, at the present time, or no surface outflow, I should say, from the project proper. So you will always have some return.

Senator ANDERSON. Has there been any effort made at any time to limit the amount of water taken in to what they are going to use?

Mr. JACOB. You mean with reasonable allowance for what is always needed above that? My answer is, "I don't know." We haven't had that under investigation.

Senator ANDERSON. I would think that would be one of the first questions you might look into.

Mr. JACOB. We weren't asked that question and we didn't look into the matter.

Senator ANDERSON. Well, you were asked to find out what causes it, and one of the reasons is that you get too much.

Mr. JACOB. That's right; but whether——

Senator ANDERSON. I want to know what you are going to do about it.

Mr. JACOB. But whether there has been any attempt in the past to limit, we don't know. We haven't studied that. Sir, we give our advice later as to what should be done, as you will find.

Senator ANDERSON. Well, do you recommend in your advice that they cut down the amount they are going to use?

Mr. JACOB. The amount that they use, plus the amount that is needed in excess of that ordinarily; yes. That is good irrigation practice. The same would apply to all contiguous projects also. It is uniquely a problem of the mesa, but it is a general problem; we so stated.

Senator HAYDEN. Don't you find in your travels over the world that the ordinary irrigator is inclined to put more water on the land than it actually needs to grow crops?

Mr. JACOB. Yes; I think that we do that. But let us remark that we must have an excess to prevent ruining the soil through salts. There must always be an excess in addition to what the plants themselves use, and that which is evaporated from water surfaces and from the soil, you always have to have some excess. It depends upon the chemical quality of the water. In many areas that is small; in other areas, it is large.

Senator HAYDEN. But aren't there devices now that a good farmer uses to test the soil to determine how much humidity there is in it and whether it needs irrigation or not?

Mr. JACOB. Yes; I believe there are such.

Senator HAYDEN. They don't do it by guess?

Mr. JACOB. No; it is not guess. With the cooperation of the Agriculture Department and the Bureau of Reclamation, I am sure that this is no longer guesswork.

Senator HAYDEN. My information is that generally the farmers are inclined to use more water than is absolutely necessary to grow their crops. They look at the surface and don't see just what the situation is of the soil itself. On the other hand, many of them, particularly grain growers, like preirrigation, and cottongrowers get water moisture down at least 6 feet in my area to feel that there would be some there for the roots to get when the time comes.

I do remember hearing at the beginning of the period when irrigation first began on the Yuma Mesa, much to my surprise, that some people had used as much as 11 acre-feet of water a year for irrigation purposes. Well, the assumption was that it was awfully dry up there, but that in due time, why, they wouldn't have to use that much.

Congressman UDALL. Mr. Jacob, this sandy type of desert soil we have here does require a higher application of water than normal?

Mr. JACOB. There is no doubt about that. It requires higher frequency and great total depth. I don't want——

Senator ANDERSON. Let's get back to that a minute. If it requires that, why don't you use it consumptively? You say that 260,000 acre-feet is imported and they use 100,000 acre-feet of it.

Mr. JACOB. The reason it isn't used consumptively is this: That in order to provide the moisture available to the plant roots so that they can get what they need, because of the sandy texture of the soil and high permeability, there must be of necessity a greater excess than with tighter soil. So you have to face that. That is inevitable with that kind of soil. There is no doubt about that.

Senator ANDERSON. Didn't the Bureau of Reclamation make a report on the type of soil when it had the project approved?

Mr. JACOB. Exactly. The Bureau of Reclamation definitely did classify the land as to its irrigability in the beginning before the project authorization. That is a matter of record. That is not a matter of concern to us in our terms of reference. But that was done definitely, as it is done on every reclamation project; the land is classified and the probable water needs are predicted.

Senator ANDERSON. Is it A, B, or C land?

Mr. JACOB. I am not sure just how it is classified, exactly how it would fall under your classification. I would have to refer——

Senator ANDERSON. But you have been studying this project, haven't you?

Mr. JACOB. We have been studying this project, sir, but we were not concerned with what the irrigability of the land was when the project was authorized, that was no concern of ours. We are concerned with what the situation is today, how it may be remedied.

Congressman UDALL. Do you have an opinion from what you see now as to whether or not the Bureau, considering the type of soil on the mesa, should have anticipated that a ground-water problem would arise?

Mr. JACOB. Would you phrase that again? I didn't quite follow you, Congressman.

Congressman UDALL. On the basis of your studies and your experience as a hydrologist, should the Bureau of Reclamation, taking into account the type of soils on the mesa, have anticipated that a high amount of water would have to be applied and that quite likely this condition which apparently has resulted would result?

Mr. JACOB. The only answer I can give to that would be, and this perhaps isn't a satisfactory answer here, but it would be to refer to the report leading to the request for an authorization to the project and/or refer to the representatives of the Bureau who are here. Personally, I can not give an opinion on it.

Senator ANDERSON. I am a little perplexed here because I read your instructions from the Secretary of the Interior which you quoted a while ago. He said:

> * * * shall make a review of all presently available data pertinent to the relationship, if any, of irrigation of the Yuma Mesa Division * * * to the levels of the water table underlying the Valley Division.

Mr. JACOB. Right.

Senator ANDERSON. Now, how in the world could you make that if you didn't know anyting about how much water it was going to take to irrigate the type of land that it was going to be? If it is a tight type of soil and not a sandy type of soil, then you wouldn't have this problem, would you? You wouldn't need 260,00 acre-feet when you were going to use only 100,00 acre-feet?

Mr. JACOB. They would still have the problem, with the same 15 acre-feet per acre per annum being applied.

Senator ANDERSON. They would? You mean they would put out 15 acre-feet when it didn't run off?

Mr. JACOB. If they had had a tighter soil, then they would have had a more serious problem on the mesa also. So perhaps that is a hypothetical question.

Senator ANDERSON. I thought when a man irrigated his land he didn't put on more water than it needed to produce a crop.

Mr. JACOB. Well, that is an ideal, but not the American habit, let's put it that way.

Senator ANDERSON. I have lost a little land because a man irrigated too much.

Mr. JACOB. You see, here on the mesa they have excellent drainage, so it isn't a problem except for the area affected to which we refer. The soil, being sandy, provides excellent drainage.

Senator ANDERSEN. Then isn't that a part of your problem?

Mr. JACOB. That is part of our problem, yes. But as to why, as to what happened in the authorization of the project, whether or not the Bureau of Reclamation cited the ground-water problem at that time, I am not qualified, because of my knowledge, to give an answer. I personally do not know.

Senator ANDERSON. I just thought curiosity might have prompted you to try to find out if they knew when they authorized the project that the character of the soil was such that it was going to take 260,000 acre-feet where only 100,000 of it would be used consumptively.

Mr. JACOB. Sir, knowing the stature of the engineers of the Bureau of Reclamation, my conclusion is that they did so. But from my own personal reading of the reports, I can't answer that.

Congressman UDALL. May I endeavor to further illuminate this. I think a central question that we have, if not the central question we

are getting at here, to determine the responsibility of the Congress, is whether poor planning, failing to take into acount the factors the Senator is mentioning, was the original fault in this thing; and, if so, then we will shoulder that responsibility if it does belong on an agency of the Government. But I think it is a central question; I hope you do come up with an answer to that question.

Senator ANDERSON. That is exactly why I asked the question. If somebody comes in and asks for relief from the Federal Government, I want to know what the Federal Government has done to cause them to ask for relief. Now if the Federal Government went in and designed the project on top of the mesa that is going to destroy the land below the mesa, then it has some responsibility. And as I understood the able Senator from Arizona and the Congressman here, they are trying to find that out also.

If this is not the fault of the Federal Government in any way, if the Bureau of Reclamation did take all the factors into consideration and did not overlook any of these possibilities, then the problem shifts to the people who are below in the valley themselves. There are lots of lands in the country where the water table is rising, not because of an irrigation project next to them.

Mr. JACOB. I think we are in essential agreement. It is just that perhaps we didn't read as much into the terms of reference as you gentlemen now read. And I should say something about the shortness of time allowed us.

We had 5 weeks in which to review all the reports, visit the area, and interview all of the people who are technically informed on the problem, and then come up with our own answers. Now had we had longer time and had we had more definite contact with the Secretary's Office, I am sure that these things would have been included in our consideration.

I am not a competent witness to answer parts of that question. I think that our report does fix the responsibility in a physical way, as far as the origin of the water.

Now as to blame or as to obligation, we don't go back into the history of the project to settle that in this investigation. We have not examined the documents and reports in that period before the authorization of the project to be able to do that. We did not think that that was part of our job.

Senator ANDERSON. Have you read any of the reports bearing upon the feasibility of the valley project or the Yuma-Mesa project or the Yuma Irrigation District?

Mr. JACOB. I personally have not. However——

Senator ANDERSON. Did the firm of Tipton & Kalmbach, did they look at them?

Mr. JACOB. Yes; they have.

Senator ANDERSON. What did they find out?

Mr. JACOB. I am not able to speak for them, I am sorry, sir, today.

Senator ANDERSON. You were consulting with them. Didn't they tell you?

Mr. JACOB. No, they didn't.

Senator ANDERSON. Then they kept it as a secret from you?

Mr. JACOB. There were no secrets among us, but we just didn't get to that point in our discussion. I am sure that Mr. R. J. Tipton, were he here, could answer that question because of his former contacts

with the area and knowing something about the history of the feasibility reports and the project itself. I do think that much more competent witnesses on that subject would be representatives of the Bureau itself.

May I continue, sir?

Senator ANDERSON. Yes.

Mr. JACOB. Continuing with the reading of the report from page IV, second paragraph:

> In respect to the Yuma Valley for the year 1955, it is estimated that 280,000 acre-feet was imported, of which 164,000 acre-feet is estimated to have been consumptively used, leaving a return of 116,000 acre-feet. During that year 106,000 acre-feet of subsurface and surface drainage was pumped at the Mexican boundary, leaving 10,000 acre-feet. During the same year drainage wells and sumps pumped a total of about 31,000 acre-feet, of which about 2,000 acre-feet was pumped into the drainage system, the remaining 29,000 acre-feet being pumped into the canal system.
>
> The amount pumped during the year 1955 from wells and sumps is in excess of the estimated importations underground from the mesa for that year. However, over the past 8 years it is estimated that the average inflow from the Yuma Mesa to the Yuma Valley underground averaged 29,000 acre-feet year year—.

I can parenthetically remark there that there has been a falling off of that quantity in recent years. The average for the last 8 years has been 29,000 acre-feet per year; for the calendar year 1955 it is only 25,000, or something less.

Senator ANDERSON. Let's see if we can follow this, then. You dealt with the average of the last 10 years?

Mr. JACOB. Last 8 years, sir.

Senator ANDERSON. Last eight. But the last 3 years you ended up with a deficit, didn't you, actually in the area?

Mr. JACOB. No, not exactly a deficit.

Senator ANDERSON. Well, if you pumped more than was left, the table should have been going down in the valley, shouldn't it?

Mr. JACOB. We should put into this question the interflow between the two areas.

Senator ANDERSON. You mean the valley is dumping it back on the mesa?

Mr. JACOB. No, coming the other way.

Senator ANDERSON. Well, if you pump more out than comes in, it ought to drop, shouldn't it?

Mr. JACOB. Now, it isn't exactly true that we pump out more than came in. Apparently, on the face of things——

Senator ANDERSON. Now let me get your figure again. We will take the year 1955.

Mr. JACOB. Right.

Senator ANDERSON. You say they imported 280,000 acre-feet and used 164,000 acre-feet, leaving a return of 116,000 acre-feet?

Mr. JACOB. Right.

Senator ANDERSON. During that year, 106,000 acre-feet were pumped at the Mexican border.

Mr. JACOB. Yes.

Senator ANDERSON. How much does that leave?

Mr. JACOB. That still leaves 10, sir, which is positive.

Senator ANDERSON. During the same year drainage wells and sumps pumped a total of 31,000 acre-feet?

Mr. JACOB. Yes.

Senator ANDERSON. What did they do with that?

Mr. JACOB. They put 2,000 into drains and 29,000 into the canals and reused it. Now the missing item of the inventory is the interflow between the two, which we estimate to average over 40,000 acre-feet here. It isn't clearly indicated here, but it follows in the paragraphs to come.

Senator ANDERSON. Interflow between what?

Mr. JACOB. Between Yuma Mesa underground to Yuma Valley.

Senator ANDERSON. Well, does it interflow back and forth?

Mr. JACOB. No. I mean in one direction; subsurface flow from Yuma Mesa to Yuma Valley.

Senator ANDERSON. All right.

Mr. JACOB. It is true that this doesn't give a closed balance and the other item is necessary to make sense, that is true.

The amount pumped during the year 1955 from wells and sumps is in excess of the estimated importations underground from the mesa for that year. However, over the past 8 years it is estimated that the average inflow from the Yuma Mesa to the Yuma Valley underground averaged 29,000 acre-feet per year, while the pumpage from the drain wells and sumps averaged only about 17,000 acre-feet per year.

Senator ANDERSON. Let's go back again. How much do you say the interflow amounted to?

Mr. JACOB. Twenty-nine thousand acre-feet per year on the average over the last 8 years.

Senator ANDERSON. And how much did the Yuma Valley District pump?

Mr. JACOB. Seventeen thousand.

Senator ANDERSON. On an average?

Mr. JACOB. An average; yes.

Senator ANDERSON. What was it this last year, let's say?

Mr. JACOB. This last year?

Senator ANDERSON. 1954–55.

Mr. JACOB. For the calendar years 1954 and 1955?

Senator ANDERSON. Yes.

Mr. JACOB. Well, sir, in the calendar year 1955, if I may, as I have that for convenient reference, they pumped 29,000.

Senator ANDERSON. Pumped 29,000?

Mr. JACOB. That's true.

Senator ANDERSON. And what was the interflow?

Mr. JACOB. The interflow is estimated to be not less than 25,000.

Senator ANDERSON. So that, if the interflow is only 25,000, they pumped out 29,000; they should have gained 4,000, should have dropped the water table that much; is that right?

Mr. JACOB. Or taken it from their own return, you see. They had an excess of imports over consumptive use.

Senator ANDERSON. We are trying to find out what the problem is in the valley. If they are pumping out more than they are taking in, they ought to be getting better in the valley; shouldn't they?

Mr. JACOB. Well, better in what sense? You mean by the decreasing of the ground-water storage?

Senator ANDERSON. That's right.

Mr. JACOB. I think, if I could refer to figure 8 of this report, I could clarify this. May I do that?

Senator ANDERSON. Yes.

Mr. JACOB. May I use slides, which are nothing but a copy of this? I believe it might help if I could.

Senator ANDERSON. Well, yes.

Mr. JACOB. This is a schematic diagram which intends to show our inventory of the water applied to Yuma Mesa in the year 1955 and that applied to Yuma Valley during the same year. Now I might remark that attempting to make a year-to-year inventory, because of the accuracy of the data, this is not possible with the kind of closure, the kind of consistency between the numbers that you would like. That is why we resort to these 8-year averages and, also in the report, to four 2-year periods. But for the purpose of demonstration, to get it down to a yearly figure which is tangible and easy to remember, we have put such a diagram into the record.

This slide is a reproduction of figure 8, following page 63 of our report of November 1, 1956, which has been included in the record of this hearing.

Senator ANDERSON. At this point, figure 8 will be printed in the record of the hearing.

Mr. JACOB. Now, on the right-hand side—I don't know how many of you can read it, and we didn't have time to prepare slides specially for the hearing; these are merely copies of the report diagrams.

With respect to the Yuma Mesa, on the right-hand side of the diagram, we have shown on a scale, this blued-in area, the various items of flow. As you can see, in the year 1955, roughly, 260,000 acre-feet of water was imported from the Colorado River. Of that 100,000—we have shown it schematically—half on this side and half on the other side went to consumptive use, used by the plants, used in the operation of projects above ground, leaving returns—and the returns in this case, as I stated before, are all ground-water recharge, for there is no surface return from the area—leaving a ground-water recharge by subtraction, then, of 160,000 acre-feet per year. We have shown it split, half and half here.

Now we have by calculation, not by opinion but by calculation, estimated which part of this ground water that recharges the water table under the mesa went into storage under the mesa by raising that water table and which part went to outflow from the mesa area, that is, beyond the escarpment of the mesa to either side. This is a calculation, not an opinion. It has a certain margin of error, admittedly, but it is a calculation.

We calculate that 124,000 of the 160,000 recharged went into storage by raising the water table, leaving 36,000, which must have flowed out, because by the laws of nature the inflow must equal the storage plus the outflow.

Now we also have a way of calculating the division of this flow, and we divided it as 25,000 flowing out during that year to Yuma Valley and 11,000 flowing to South Gila underground. Now, I wish to remark that this flow takes places in the gravel aquifer which is near sea level and below sea level. There is very little horizontal flow in the material above that aquifer, as was found by the Bureau of Reclamation in their report in 1952, very little flow in that top material. But in the bottom material there is a very permeable gravel aquifer which is utilized in the area for supply. That is, in that gravel aquifer that the flow takes place, and it descends down to about

SCHEMATIC FLOW CHART SHOWING DISPOSAL OF
WATER IMPORTED TO YUMA VALLEY AND YUMA MESA 1955
AND INTERFLOW BETWEEN THE TWO AREAS

Numbers give flow in thousands of acre-feet per year.

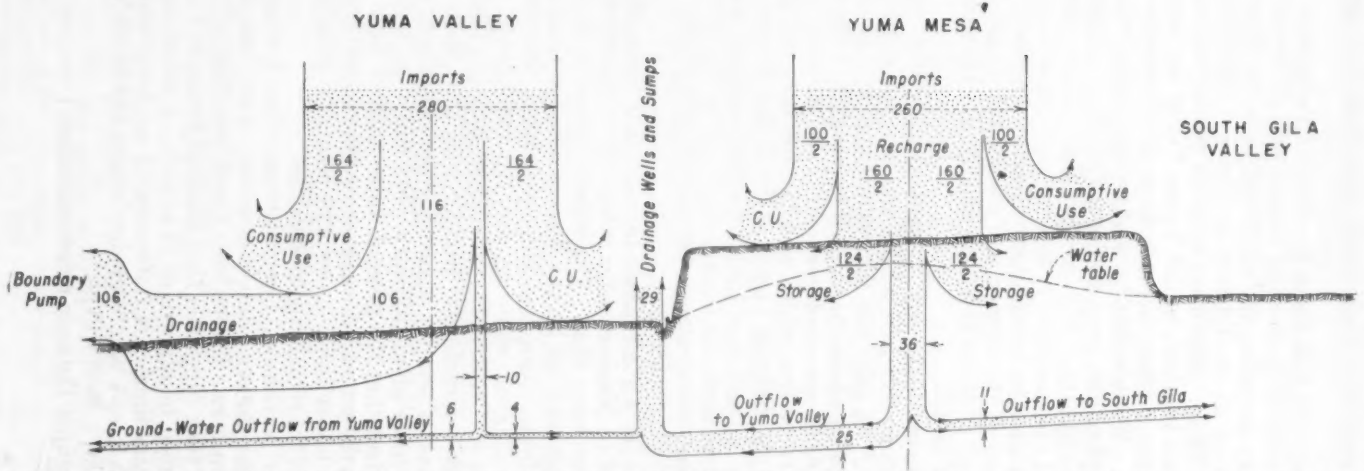


FIGURE 8. Report on Ground Water and Drainage of Yuma Mesa and Yuma Valley; by Tipton & Kalmbach, Inc., and C. E. Jacob, November 1, 1956.

sea level and flows horizontally and then rises again as opportunity permits.

Now, let's not talk about the South Gila because we need no closure of the inventory there, and indeed our closure of inventory on this side is only tentative, for we do not have the data to make as precise an inventory as we did here in Yuma Valley, and as we have made in Yuma Mesa. However, this is a tentative inventory of the water which came in, then, to the Yuma Valley by imports, and these are only visible surface imports from the Colorado River, of 280,000 acre-feet. We calculate by well-known methods based on experiments made on plots and from analogy with other irrigated areas, knowing the crops and so on. We calculate that 164,000 acre-feet of the 280,000 were used consumptively, leaving as total returns 116,000 acre-feet. Now this was the point where Senator Anderson saw a looseness in the balance of the figures, and we wanted to know what the missing figure was. I think this may clarify it. He saw that it didn't add up, and it didn't.

That leaves 10,000 and I want to emphasize to you that this has a great error, this part of the diagram has a great residual error in it. But if we take our figures without any changes, we get 10,000 excess returns above that which is pumped at the boundary pumping station, 10,000 acre-feet per year. We see that in order to produce the 29,000 acre-feet, which we know has been pumped by the drainage wells and the drainage pumps of the Valley Waters Users' Association, that there is a deficit of 4,000. Because we have only 25,000 calculated coming from here, we must make it up by the 4,000 which is returns, excess above the drainage pumped, leaving 6,000 to flow out to the river.

Now we have good reason to know that the outflow to the Colorado River and to Mexico on the other side is greater than 6,000 acre-feet a year; we know that. The reason we don't change the diagram is because we want to let the figures talk for themselves, and then we qualify them. Now had time permitted, we would have prepared a similar diagram showing, say, the average for the last 8 years. I think you will realize that the more data you get, the better you are able to get a meaningful balance with that data, being as true as it is; whereas, if you try a year-to-year inventory, the engineers know that you have great difficulty. So, this does have that aspect. We are confident that the ground-water outflow from the mesa to Yuma Valley in the year 1955 was greater than 25,000 acre-feet a year. Just what the upper limit is, we will return to that in the course of the reading of the remaining conclusions.

Senator ANDERSON. I regret to say that I made a commitment to talk to the Rotary Club this noon. They had found I was going to be down here. I have been a past president of the world organization, and they suggested that I talk to them, so I agreed to that.

We agreed to adjourn at 12 o'clock. I would be happy to continue and let him finish his testimony, if anybody wants to stay and let him finish it, or I will be glad to return and be with you again at 1:30.

All right, 1:30 it will be.

(Whereupon the noon recess was taken.)

AFTER RECESS

Senator ANDERSON. The hearing will please come to order. Mr. Jacob, you may continue with your testimony.

Mr. JACOB. All right, sir.

Continuing reading from the synopsis of the report, the middle of page iv:

The amount pumped during the year 1955 from wells and sumps is in excess of the estimated importations underground from the mesa for that year. However, over the past 8 years, it is estimated that the average inflow from the Yuma Mesa to the Yuma Valley underground averaged 29,000 acre-feet per year, while the pumpage from the drain wells and sumps averaged only about 17,000 acre-feet per year.

Although apparently the corrective measures progressively effected by the Yuma County Water Users' Association have not kept pace fully with the increased importation to the valley from the mesa, nevertheless it is concluded that there has been very little, if any damage to the valley lands up to this time because of the irrigation of the lands on the mesa. This in part is because of a change of regiment of the flow of the Colorado River and its channel, which has been of some benefit to the valley. Since Hoover Dam went into operation few sustained flood flows have passed the project and during the last few years the channel has degraded. During recent years also, the total flow in the Colorado River passing the project has been much less than formerly. This has had the effect of lowering the water table along the western portion of the project. It is probable that this has resulted in the discharge of a greater quantity of ground water from the east to the west and southwest into Mexico.

It is concluded, however, that unless the addition of drainage facilities keeps pace with increased importations from the mesa area, material damage will result to a portion of the valley lands, particularly those lying on the eastern edge under the mesa. Those lands which would be damaged first and damaged the most severely would be those lying in what is known as the Big Bend area.

It is concluded that importations by subsurface interflow from the mesa to the valley will progressively increase. For the period 1953–55 it has already been shown that of the 260,000 acre-feet per year of water imported to the mesa, it is estimated that 124,000 acre-feet per year went into storage. If the large importations, which at the present time average about 15 acre-feet per acre of lands irrigated continue, the ground-water reservoir lying under the mesa inevitably will fill, which will cause the seepage of lands on the mesa and will eventually require the drainage of those lands.

If the surface-water importations to the mesa remain high, the water which now is going into storage must find its way to adjacent low-lying areas, including the South Gila project, the—

That should be Yuma Valley project. That is another error that escaped our detection—

the Yuma Valley project, and Mexico. Probably more than 150,000 acre-feet of water per annum will be involved in this movement. If the irrigated area on the mesa is extended with further importations at the same rate in acre-feet per acre as the present importation, the quantity of water to be disposed of by ground-water movement each year will be increased still further.

It is apparent that the problem cannot be confined to a limited area. It has a regional aspect. A hydrological region now involved and to be involved to a greater extent in the future includes the Wellton-Mohawk area to the east, the South Gila area, the Yuma Mesa, the Yuma Valley, and Mexico on the south and the west. Most of this region is underlain by a highly transmissive coarse-gravel aquifer, the top of which is at about sea level. It is believed that this aquifer is a controlling factor in the underground hydrology of the region.

A comparison of the results of quality of water analyses of Colorado River water, Gila surface water, and Gila ground water with the results of quality of water analyses of the deep wells in the Yuma Valley indicates that under much of the Yuma Valley the flow in the deep gravel aquifer generally comes from the Gila River Basin. A comparison indicates that the Colorado River may be supplying some water to the aquifer across the north and west portion of the valley.

Most of the wells along the east side indicate a mixing of Gila and Colorado River water, the latter probably coming from importations to the surface of the mesa.

The hydrologic regimen of the whole area will be affected if increasing amounts of water are imported to the Wellton-Mohawk and Yuma Mesa areas. The regimen also is being influenced by seepage from the All-American Canal, the Mexican system of canals diverting from the Morales diversion structure, and the water being applied to a portion of the Mexicali Valley, in Mexico. The regimen may also be affected by pumpage of water from wells in Mexico west of the Colorado River.

It is believed that the ultimate hydrologic balance of the region must be considered. The most important regional aspect of the entire problem obviously is the control and disposal of the returns of large amounts of water that are now being imported and the additional amounts that will be imported to the projects located in the region.

Time did not permit an adequate appraisal of means for coping with the problem in the valley unit of the Yuma project. One approach would be to anticipate the deleterious effect of rising water table in certain areas by means of observation wells in sufficient time to better the drainage facilities for those areas by the construction of tile drains or the installation of additional deep pump wells.

Another approach would be by means of additional field studies, to attempt to predict what the ultimate overall picture might be, and to embark upon a full-scale expansion of drainage facilities in the near future to obviate adverse effects to the low irrigated lands situated adjacent to the mesa because of increased importations from the mesa.

If the latter course is the one adopted, it is believed tentatively that for the valley the most economical and effective program would be to deepen materially the main drainage channel and, to the extent necessary, the lateral drains, and to install additional deep-pump wells at the foot of the mesa.

Another main drain running across the valley from east to west to relieve the burden on the present drainage system may be indicated. The water would be pumped from the transverse drain into the Colorado River.

Considering the entire region, it is believed also that a deep drainage channel should be constructed along the Gila River from the Narrows near Dome to the Colorado River. This channel would provide some protection to the Yuma Valley and to the South Gila project, and it would provide an outlet for any drains that might be indicated as necessary for the latter project.

The following investigational program should be carried out—

and we have very briefly summarized here the recommendations of the report. Because of the brevity of time, I shall not quote them in detail but merely their summary in the synopsis. This is the investigational program that is recommended:

1. Improve accuracy of surface water flow measurements and accounting, particularly in respect to the measurement of water deliveries and return.
2. Construct twenty-four 4-inch diameter observation wells of 200-foot depth on the Yuma Mesa.
3. Construct eighty 2-inch diameter shallow water-table observation wells on the Yuma Mesa.
4. Install six automatic stage recorders on selected wells.
5. Run seismic refraction profiles at the Narrows below Dome, at the location of the Gila Canal siphon, and along the mesa in line with the rock outcrops. Further seismic exploration may be indicated as the result of the above.
6. Make pumping tests (step-drawndown and recovery tests) on all operating pump wells on the mesa, in the valley, and in the South Gila project.
7. Observe the water level in all observation wells at not less than monthly or bimonthly intervals.
8. Take samples and make qualitative analyses of the water from representative wells and surface supplies at selected locations.
9. Make final analysis of a 2-year investigation involving the above and from final analysis make an estimate of the ultimate movement of the groundwater as storage builds up under the mesa and conceive the outline of remedial measures which ultimately should be consummated to prevent lands adjacent to the mesa from being adversely affected by irrigation on the mesa.

The reading of the observation wells to determine water levels, the sampling of ground water and surface water at selected points to determine quality, and

the maintenance of the water-stage recorders on the selected wells should be a continuing program.

It is estimated that the 2-year program outlined above would cost approximately $90,000, of which $35,000 would be for capital investment. The balance would be for services and expenses of personnel not already engaged on project operations nor incident to ordinary governmental activities in the area.

Neither information nor time permitted the estimation of the cost of those works and facilities required to prevent damage to valley lands because of increased importations from the mesa. The cost of work ultimately required will run into the hundreds of thousands of dollars.

Now, that concludes the synopsis, Senator Anderson.

Senator ANDERSON. Now, let me ask you this: The letter of instructions would seem to suggest that you review what relationship, if any, the irrigation of the upper mesa division has to the valley division and then outline the cause or causes or high-water tables, suggested remedial action and construction and estimated cost of remedial action and construction. Am I to assume from this that you feel that instead of doing that sort of thing, it would be much better first to have a 2-year study so that you might know exactly where you were going and that that 2-year study should precede any effort for present construction?

Mr. JACOB. Yes; that is correct. We feel that our answers today are what we might call 20-percent answers; that is, we claim to be able to calculate the underflow from the mesa to the valley with a probable error of 20 percent. That means that if we quote a given figure, there is a 50–50 chance that it lies within the limits we set and a 25 percent probability that it lies beyond either limit.

Now, our feeling is that with this kind of investigation that this, of course, can be greatly sharpened. This estimate can become, say, a 10-percent answer, with a 10-percent probable error. Moreover, of course, we can predict the future behavior of this system much more accurately with that additional knowledge.

I think you can see that the water is going into storage and partly to outflow. The fraction that is going to storage and to outflow at the present is known with fair certainty, but to be able to predict what that will be in the future requires a sharpening of certain factors. We would hope to be able, under the suggested program which is outlined in some detail here, to be able to do that, Mr. Senator.

Senator ANDERSON. Well, this recommendation is, "Make final analysis of a 2-year investigation. * * * Now when the Yuma Valley people were in here, the valley division people, they suggested a construction program of some 25 wells and the construction of a canal, and they thought that would run $3 million to $4 million. You have suggested a program of study that will run $90,000, of which $35,000 would be for capital investment. Do I correctly understand your recommendation to be that the Congress not appropriate $3 million or $4 million to build the other wells, but instead provide $90,000 for a 2-year study?

Mr. JACOB. Well, our recommendation is that the $90,000 be devoted to a study. This alternative of embarking now upon construction is new to us and we hadn't considered it. Speaking for myself, I would say that this is our recommendation: That any construction plans be deferred until the outcome of such an investigation is contemplated.

Senator ANDERSON. Do I also understand from this study that you don't think the condition is getting bad fast enough but what the 2 years can be safely spent?

Mr. JACOB. That is correct. I believe developments are slow enough that with existing facilities and their enlargement in accordance with present plans of the Yuma County Water Users' Association, they should be able to keep abreast of developments in the near future anyway.

Congressman UDALL. Your testimony, however, is that the picture is worsening; isn't that true?

Mr. JACOB. Yes.

Congressman UDALL. The outflow from the mesa is worsening?

Mr. JACOB. That is the picture. The picture is that there is a tendency established, which is now just being sensed and which in the future will grow larger and larger. In other words, where as presently there is more than 40,000 acre-feet per year flowing out, and about 160,000 acre-feet going into storage under the mesa, when that tank is filled up, your tank is full, and then obviously, all of the recharge upon the mesa is going to thereafter become outflow, and so you can anticipate that even with the present acreage and the present depth of application of water that you may ultimately have to take care of an additional 120,000 acre-feet as a minimum between the 2 projects, the South Gila and the Yuma Valley.

Congressman UDALL. Referring to general conclusions, because we are interested, I think, in causation here, but for the construction or the importation for the Yuma Mesa project, would the problem today be as crucial either in the Yuma irrigation district or Yuma Valley?

Mr. JACOB. As crucial as what?

Congressman UDALL. As crucial as it is today, but for the Yuma Mesa project, had it never been put into effect?

Mr. JACOB. As I understand the question, but for the Yuma Mesa having gone into operation, would the situation have been as crucial as far as these two problems are concerned? My answer is definitely no, that this is an additional importation, and we have so considered it in our balance, water balance, for the Yuma Valley. We have considered the visible importations from the Colorado River plus the hidden importations which are calculated return from the Yuma Mesa to the Yuma Valley. And so it is a definite figure that we consider as an importation, and therefore a cause for need for additional drainage.

Congressman UDALL. Yes. Now it is true, as we discussed earlier, isn't it, that in this sandy, porous soil, you need much more water than in some other types of soil?

Mr. JACOB. To grow the same crops?

Congressman UDALL. Yes, to grow the same crops.

Mr. JACOB. Yes.

Congressman UDALL. And that also taking into account the nature of the soils present, say on the mesa, that it should have been contemplated, at least, in light of what we know now, that drainage facilities of some kind would be required to avoid a critical waterlogging problem?

Mr. JACOB. Well, I agree that it should have been contemplated, and I don't believe that it wasn't contemplated. As I testified before noon, I believe there are others better qualified to testify with regard to the feasibility of reports that preceded the authorization. I believe that it should; I agree with you that it should have been contemplated.

Congressman UDALL. As a Member of Congress, I am directing my thought toward whether actually something was begun here which now must be completed and to determine what the responsibility of the Government should be, if any, in finishing the job. In other words, if we have done something which has produced a very critical situation for these farmers and it must be alleviated, then what should the responsibility of the local people be and what should the responsibility of the Government be?

Would it be possible in your future studies to arrive at some conclusion in that regard, as to how much responsibility lay where, whether the Government was entirely responsible?

Mr. JACOB. I believe that an independent engineering consultant could give his opinion as to how the responsibility ought to be divided. I think it is a juristical matter rather than a technical matter. In other words, we can place the physical responsibility, if you please, where we think it lies. Now just exactly where responsibility was preceding that, an engineer could read the reports and give his opinion, I think.

Congressman UDALL. Is that information available at the present time?

Mr. JACOB. I believe it is, yes. I believe such information is available. We did not, as I stated earlier, read that requirement into our terms of reference. We didn't read it as broadly, apparently as some others may have. In other words, we didn't think that our frame of reference included this point, and because we had plenty to do in 5 weeks we concentrated on the things that were more specific.

Congressman UDALL. Of course the other thought I have, because I know the valley farmers are concerned and this is a critical problem now, is with reference to their expense of pumping, which is on the increase and is reaching the point where it tends to overburden the farmers.

Isn't there sufficient information, or could it be ascertained without, say, a 2-year study but pinpointing certain facts that we wanted, to determine what Federal responsibility there is, so that although these other studies might be valuable, the period of time needed to further study the matter could be shortened?

Mr. JACOB. I believe with regard to the cost of the present measures that are taken in the valley to keep the water table down, that as testified by the president of the water users, they could figure that out with some variation of their cost accounting procedure. In other words, as I understand it, they have lumped operation and maintenance costs with the retirement of debt on any investments, and so there is not a division in their accounting.

If we knew the cost of their power and the efficiency of their pumps, we could of course very quickly make a calculation on the exact cost of electricity. That could be done. I am sure Mr. Johannsen's engineers could do that.

Congressman UDALL. Are you familiar with or have you seen in operation the tentative idea thrown out here by the valley concerning a concrete canal to get the water out of here and into an area where it won't cause waterlogging?

Mr. JACOB. No, I am not familiar with it.

Congressman UDALL. Have you seen that type of a drainage system?

Mr. JACOB. Elsewhere?

Congressman UDALL. In a similar situation.

Mr. JACOB. Well, I have never seen an exact analogy to what we have here, so my answer would be no, I have never seen that, and I don't believe that Mr. Tipton's firm is aware of the plans. We have not discussed them with the water users. This is the first time I heard about it, was today at the hearing.

Congressman UDALL. Does it sound like it is worth exploring?

Mr. JACOB. Well, I would not want to give an opinion without seeing the exact plan and seeing what it contemplates, and so on, compare it with what we propose here as an alternative.

Congressman UDALL. I think that is all.

Senator ANDERSON. Senator Hayden, do you have any questions of this witness?

Senator HAYDEN. No; I haven't.

Senator ANDERSON. Thank you very much.

Mr. Maierhofer, will you identify yourself for the record and state what you are and what your position is with the Bureau of Reclamation.

STATEMENTS OF CHARLES R. MAIERHOFER, CHIEF DRAINAGE AND GROUND WATER ENGINEER, BUREAU OF RECLAMATION, DEPARTMENT OF THE INTERIOR; AND JOHN HARSHBARGER, DISTRICT GEOLOGIST FOR THE GROUND WATER BRANCH, STATE OF ARIZONA, UNITED STATES GEOLOGICAL SURVEY

Mr. MAIERHOFER. I am Charles R. Maierhofer. I am chief drainage and ground water engineer of the Bureau of Reclamation. I am chairman of the committee on drainage of irrigated lands of the American Society of Civil Engineers. I have a similar position in the American Society of Agricultural Engineers, and I am on the executive committee of the International Congress of Irrigation and Drainage.

Senator ANDERSON. Thank you.

Mr. MAIERHOFER. Mr. Chairman, I have a statement here that I would like to insert in the record. It is rather lengthy. It is a joint statement by the Geological Survey and the Bureau of Reclamation, which has been approved by the Director of the Geological Survey, the Commissioner of Reclamation, and by Secretary Aandahl. Because it does contain some specific things, if you feel we have time, I would like to brief it.

Senator ANDERSON. Not only would we be glad to have you brief it, but I think you ought to brief it. We will put it all in the record at this point, and you can make comments on such sections of it as you desire.

Mr. MAIERHOFER. Fine. The following is the joint statement by the Geological Survey and the Bureau of Reclamation concerning drainage problems in the Yuma area.

Representatives of the Geological Survey and the Bureau of Reclamation met in Denver to appraise their respective views concerning the relationship between irrigation on the mesa and drainage problems in the valley. Complete agreement was found on the scientific aspects of the problem, which are summarized on pages 109 through 111 of the survey report.

The representatives of both agencies underscore the need, however, for considering the survey's conclusions and recommendations in their entirety and in conjunction with the amplified discussions given in the body of the report wherein specific parts of the valley are identified. For example, it is the Bureau's

position that because of irrigation on the mesa, some unknown quantity of water moves toward the valley, but the evidence does not indicate that there has been significant net aggravation of the overall drainage problems nor impaired productivity of the valley lands. The survey's position is that irrigation on the mesa contributes to the drainage problems in some parts of the valley. These two views are not in conflict and are thoroughly understood and endorsed by both Bureaus.

The survey's studies, made in response to requests from the Senate Committee on Interior and Insular Affairs, utilized considerable additional data, not available in previous studies, relating to the occurrence and movement of ground water in the Yuma area. Review of these and previous data permitted important new contributions to be made that promote a better understanding of the relation between irrigation on the mesa and drainage in the valley. The most important of these contributions are briefly discussed as follows:

1. A coarse-gravel zone of high permeability, occurring approximately at sea level in the Yuma area, extending under both the mesa and the valley, and averaging several tens of feet in thickness, was identified.

2. Electrical analog studies made through the Big Bend area show that the coarse-gravel zone can be highly effective in transmitting head changes resulting from irrigation on the mesa.

3. There is evidence that head changes in the coarse-gravel zone have occurred, but it is not in sufficient detail to fix their magnitude or to delimit the specific local areas in the valley in which they have taken place. The only available water-level records from wells penetrating the coarse-gravel zone are for two wells on the mesa near the southeastern limits of the ground-water mound. These wells show head rises of 20 and 25 feet. Barring any geologic evidence to the contrary, if head rises can occur on one side of the ground-water mound, they can also occur on any other side, including the valley side. This information together with additional evidence collected from deep wells in the Big Bend area is the basis for the conclusion that in some parts of the valley drainage problems are intensified. The effects on drainage resulting from these head changes in the coarse-gravel zone would be greatest in those parts of the valley closest to the ground-water mound under the mesa.

4. Review of the data on importation of surface water to the mesa and valley divisions, and the wasting or pumping of water from those divisions, shows that a complete accounting of all water movement in the area is not justified because the surface importations of water are of such large magnitude as to overshadow completely other important elements in any areal water budget. However, salt-balance studies for the valley conclusively demonstrate that importations of water, since the late thirties, have been in excess of the water needed for the crops and for maintaining satisfactory soil conditions.

The available data do not reveal whether, in specific problem areas, the particular cause of aggravated drainage problems has been excess application of irrigation water, actual upward seepage of water from the coarse-gravel zone, or loss of drainage opportunity through establishment of adverse head gradients.

As corollaries to the foregoing discussions the following questions are posed and data obtained from public records are furnished. Subject to the limitations inherent in the analytical methods used, an answer to each question may be drawn. Undoubtedly many additional questions could be posed; those that follow, however, bear upon some important aspects of the drainage situation in the valley.

1. Has there been a rise in the average elevation of the water table, throughout the valley lands, since the beginning of irrigation on the mesa?

The record is given in the following table, wherein the averages have been determined by the method of Thiesson polygons using selected wells throughout the valley.

Year	Average water-table elevation	Year	Average water-table elevation
1942	99.5	1949	99.8
1943	99.4	1950	99.4
1944	99.3	1951	99.2
1945	99.6	1952	99.6
1946	99.5	1953	99.1
1947	99.2	1954	99.5
1948	99.8	1955	98.9

2. Has there been a rise in the average elevation of the water table throughout the east half of the valley, between the mesa and the central main drain, since irrigation began on the mesa?

The record is given in the following table wherein the averages have again been determined in the manner already described.

Year	Average elevation	Year	Average elevation
1942	101.3	1949	101.8
1943	101.0	1950	101.6
1944	101.1	1951	101.5
1945	101.6	1952	101.6
1946	101.8	1953	101.4
1947	101.4	1954	102.0
1948	101.7	1955	101.9

3. Has there been a rise in the average elevation of the water table in specific areas of the valley since irrigation began on the mesa?

Water-table elevation show a persistent rise in the northeastern part of the valley south of Yuma and in an area southwest of the Big Bend area. The maximum rise observed in either areas has been about 2 feet since 1942. In both areas the present depth to ground water is about 3 feet along the east main canal, about 8 to 11 feet some 4 miles west of the canal. In the history of both areas there is evidence of occasional higher ground-water elevations.

4. Has there been a reduction in irrigable lands in the valley since mesa irrigation?

The irrigable acreage has increased and the area out of production due to adverse drainage conditions has decreased, as shown by the following data from the annual project histories:

Year	Total irrigable acreage	Acreage out of production due to adverse drainage conditions	Year	Total irrigable acreage	Acreage out of production due to adverse drainage conditions
1940	49,135	1,090	1947	48,787	1,603
1941	49,271	1,106	1948	49,705	585
1942	49,068	1,163	1949	49,556	335
1943	49,251	1,184	1950	52,591	400
1944	49,273	1,173	1951	52,591	400
1945	49,216	1,178	1952	51,510	0
1946	49,063	1,307	1953	51,936	0

5. Has there been an increase in net water imported to the valley lands since mesa irrigation?

The record is given in the following table:

Year	Net water imported exclusive of deep well pumping, acre-feet	Year	Net water imported exclusive of deep well pumping, acre feet
1941	230,000	1949	270,000
1942	230,000	1950	280,000
1943	250,000	1951	290,000
1944	240,000	1952	300,000
1945	240,000	1953	290,000
1946	270,000	1954	290,000
1947	270,000	1955	280,000
1948	270,000		

6. Is this increase due to increased water applications?

The following table shows the net water imported in terms of acreage irrigated, excluding water pumped from deep wells:

Year	Net water imported in acre-feet per acre irrigated	Year	Net water imported in acre-feet per acre irrigated
1942	5.0	1949	5.8
1943	5.4	1950	5.9
1944	5.3	1951	6.3
1945	5.3	1952	6.3
1946	5.9	1953	6.2
1947	5.9	1954	6.4
1948	5.8	1955	6.1

Some of the water obtained by pumping the deep wells can be considered a net import into the valley; best engineering judgment indicates that it is a substantial portion. Total volume pumped in 1955 was about 15,000 acre-feet, but available data do not permit estimates of the portion coming from outside the valley.

7. Has the volume of water pumped at the boundary pumping plant increased since irrigation began on the mesa?

The increase in pumping at the boundary pumping plant accompanies the increase in net water imported to the valley. The following table shows a comparison between net water imported per acre irrigated, and water pumped at the boundary plant per acre irrigated.

Year	Acres irrigated	Net water imported (acre-feet)	Pumped at boundary pumping plant		Net water imported (acre-feet per irrigated acre)
			Total (acre-feet)	Acre-feet per irrigated acre	
1942	46,000	230,000	70,000	1.5	5.0
1943	46,000	250,000	70,000	1.5	5.4
1944	45,500	240,000	65,000	1.4	5.3
1945	45,500	240,000	55,000	1.2	5.3
1946	46,000	270,000	70,000	1.5	5.9
1947	45,500	270,000	90,000	2.0	5.9
1948	46,500	270,000	85,000	1.8	5.8
1949	46,500	270,000	95,000	2.0	5.8
1950	47,500	280,000	90,000	1.9	5.9
1951	46,000	290,000	90,000	2.0	6.3
1952	47,500	300,000	110,000	2.3	6.3
1953	47,000	290,000	110,000	2.3	6.2
1954	45,500	290,000	105,000	2.3	6.4
1955	45,500	280,000	105,000	2.3	6.1

8. Does the ground-water flow from the mesa to the valley appear in the increased pump load at the boundary pumping plant?

An unknown quantity of ground water undoubtedly flows from the mesa, some of which reappears as shallow ground water in the valley, and some leaves the general Yuma area through the deep-gravel aquifer. The contributions to the shallow ground water constitute an added burden on the valley drainage system. Concurrently an additional burden has been imposed by the valley itself in the form of substantially increased water imports and heavier applications per acre. Considering the entire valley the increased pumping load at the boundary pumping plant is consistent with the increased imports. Two other factors pertinent to the problem are contributions from the mesa on the east, and increased outflow to the Colorado River on the west due to improved channel conditions from the Hoover Dam operations. These are plus and minus factors of about the same magnitude.

9. Can the ground-water flow from the mesa to the valley be isolated and accurately estimated?

The available data do not permit an estimate. Even additional data obtained at prohibitive costs would permit only an approximation.

10. Have drainage measures taken by the valley prevented damages which would otherwise have occurred because of irrigation on the mesa?

Some portion of the water pumped from the wells tapping the coarse-gravel zone has prevented damages in some areas. There is reason to question whether these measures constitute the most economical method of drainage relief.

With reference to the specific problem—whether water applied for irrigation on the mesa affects the drainage problem in the valley—the following conclusions may be drawn:

1. Overall drainage conditions in the valley are no worse since irrigation began on the mesa.

2. The eastern portion of the valley has experienced an additional drainage burden; the western portion has experienced a reduced drainage burden due to the changed regimen of the Colorado River.

3. Specific quantities involved cannot be dfietermined accurately with data available or data which could be obtained at practical cost.

The foregoing discussion, comments, questions, and answers comprise a joint effort by representatives of the Bureau of Reclamation and the Geological Survey. Both agencies reaffirm their complete agreement on the scientific features of the problem; both emphasize that quantitative answers, heretofore considered vital to a solution of the drainage controversy, are likely to be achieved only at costs far greater than the costs of constructing drainage works that would provide adequate protection.

Both agencies join in the plea that equitable resolution of the drainage controversy be founded on an unbiased scientific basis.

OCTOBER 1956.

Mr. MAIERHOFER. Mr. Harshbarger is here with the Geological Survey.

Senator ANDERSON. Mr. Harshbarger, will you come up, please, at the same time.

Mr. MAIERHOFER. There have been some misconceptions, apparently, in various quarters as to the opinions of the Geological Survey and the Bureau of Reclamation on these matters. Actually, on reading the reports of both agencies carefully and studying the technical matter in them, there is not disagreement, and for that reason we have this joint statement, which I will brief.

There is complete agreement on the scientific aspects and the views are not in conflict. The Bureau of Reclamation believes that some water moves to the valley, that there is no significant net aggravation, and that there is no impairment of productivity. The Geological Survey believes that the mesa contributes to drainage problems in some parts of the valley. The Survey found in its study that a coarse, thick gravel zone of higher permeability underlies the mesa and the valley at sea level. The coarse-gravel zone can transmit head changes to the valley from mesa irrigation. Some head changes have occurred, but their magnitude cannot be fixed and the locations of their effects cannot be delimited. They would be greatest nearest the ground-water mound on the mesa. A complete accounting of ground-water movement is not justified because the quantities are not significant in relation to the magnitude of the surface-water importations. The data do not reveal whether the problems are due to excess applications of irrigation water, upward seepage from the gravel zone, or loss of drainage opportunity because of adverse head gradients.

To clarify some of the most important points, our joint statement contains some questions. Along with the questions are data taken from public records to answer the questions. I will not give the data in this brief.

Mr. Chairman, if you do have questions as I go into these things, we have the data here and we can get them out quickly.

Senator ANDERSON. I was going to let you finish your statement of briefing and then we can come back to it.

Mr. MAIERHOFER. Good. There has been no significant rise of average water-table levels in the valley since mesa irrigation.

Senator ANDERSON. Let's have that again.

Mr. MAIERHOFER. There has been no significant rise of average water-table levels in the valley since mesa irrigation. There has been no significant rise of average water-table levels in the valley between the central main drain and the mesa. There has been a persistent rise of water-table levels in the northeastern part of the valley south of Yuma, and in an area southwest of the Big Bend area. The maximum rise in water-table level has been 2 feet since 1942. The present depth of the water table is 3 feet along the east main canal, about 8 to 11 feet some 4 miles west of the canal. Historically, there have been higher water levels in both areas.

Senator ANDERSON. When you say "historically," about how far back to you go on that?

Mr. MAIERHOFER. That comes out of Geological Survey report records, and we also have it. John, do you recall? It went back in the twenties, as I remember?

Mr. HARSHBARGER. 1916, I think.

Mr. MAIERHOFER. Thereabouts; quite old.

Senator ANDERSON. Now, your water table is 3 feet in 1 section now?

Mr. MAIERHOFER. Yes, sir.

Senator ANDERSON. Do I understand it to be your testimony that it has been 3 feet before?

Mr. MAIERHOFER. It has been 3 feet before.

Senator ANDERSON. Was that before the mesa irrigation started?

Mr. MAIERHOFER. Yes. By "historically" we are referring back to the old days, the twenties, 1916, or thereabouts.

The irrigable acreage in the valley has increased since mesa irrigation, and the area out of production due to adverse drainage conditions has decreased to zero in 1953. Since that time we do not have the records. They, I believe, are kept by the Yuma County Water Users' Association, and I am sure they would have better information than we have since 1953.

Senator ANDERSON. Will you repeat that statement again, please?

Mr. MAIERHOFER. Irrigable acreage in the valley has increased since mesa irrigation, and the area out of production in the valley due to adverse drainage conditions has decreased to zero in 1953.

Senator ANDERSON. You have got me a little perplexed now. I mean I am wondering why this claim, then, that the mesa has damaged the valley. If the valley had a short distance to water previously, and if the area that is out of production because of flooding has decreased to zero, who is damaged? And how much?

Mr. MAIERHOFER. I think possibly it enters into a matter of agency philosophy as you know, the Bureau of Reclamation is in the business of producing crops and reclaiming land. We have found no reduction of crop-growing activity. We have found no reduction of land suitable for irrigation and producing crops.

Whether 10,000 acre-feet of water or 50,000 acre-feet of water go from 1 place to another, to me is unimportant, unless it reduces the production of crops, which is our business. The other thing, to me, is legal.

Now, I don't infer that some damage is not created. If someone has to pump more water because of another operation, legally possibly they are damaged.

Senator ANDERSON. Their only damage, if they have financial damage, is the amount of the bill they have for running the pumps, plus depreciation on the pumps. It would seem to me the only measure of damages you have is how much did it cost to pump.

Mr. MAIERHOFER. That is my feeling. It is a personal feeling, however, and we kept that type of conclusion out of our joint statement. It is a thing either for the courts or Congress to decide. We don't know definitely. As Dr. Jacob indicated, there is water moving into the valley from the mesa.

Senator ANDERSON. Yes. But unless you can show that you are being damaged by that, then you certainly can't expect to recover except for the damage as you can show.

Mr. MAIERHOFER. Well, that is my feeling. There is this to say, as Dr. Jacob pointed out. With that water not being pumped, there would be damage; possibly now, possibly not yet, possibly 10 years from now. We don't know. There is some indication that ground water is stabilizing under the mesa and the valley. Perhaps it will become serious, perhaps it will become just a bit more serious. We don't know.

I might add one other thing there for clarification. Are you familiar with what we call irrigable acreage?

Senator ANDERSON. Yes.

Mr. MAIERHOFER. It is land that is assessed water charges. That land has increased consistently through the years to where the amount that is eliminated from assessment of water charges had become zero in 1953.

The net water imports to valley lands have increased since mesa irrigation. The quantity of water applied per acre to valley lands has increased since mesa irrigation.

The water pumped at the boundary pumping plant has increased since mesa irrigation. The increase is about equal to the increased imports to the valley.

Some of the water pumped at the boundary pumping plant is from the mesa. Some mesa ground water leaves the area through deep gravel aquifers; some valley ground water flows out due to improved channel conditions of the Colorado River since Hoover Dam. All are plus and minus factors of about the same magnitude.

What we are saying there is that is some water coming off the mesa which is normal, and there is some water going out from the central main drain west to the river. That quantity of water is roughly equal to the quantity of water coming from the mesa, is roughly equal to the increased pumpage at the boundary plant, is equal roughly to the magnitude of the increased water importation.

We have got four things that appear to be more or less equal. This is why we feel we have a condition of stability within the water table within the valley. The averages have remained the same. That does not mean that specific areas have not been hurt. They may be higher in one place, lower in another. The net has remained the same.

The quantity of flow from the mesa to the valley cannot be estimated from available data. Prohibitive costs would permit only a weak estimate.

Now I have great regard for Dr. Jacob and Mr. Tipton. They have wide experience, and that is one point where we differ. We feel possibly for $100,000 you might get some answers, possibly for $500,000, you wouldn't get anything. It is a gamble, is the way we look at it.

The drainage measures taken by the valley have prevented some damage from mesa irrigation. The method of these drainage measures is questionable economically.

I might expand slightly on that, if you will permit me.

Senator ANDERSON. All right.

Mr. MAIERHOFER. We feel that pumping from this deep aquifer is undoubtedly doing some good. We also feel that a very high percentage of the water pumped is not the water that is causing damage. We feel that where there is damage a specific area should be isolated, studied, and a determination made as to whether pumping for the substrata conditions in that specific spot is more economical than subsurface drainage. Subsurface drainage—tile drains, open drains, are the best thing for one condition; pump wells are best for another condition. We feel that a good part of this annual pumping, while it is good water and undoubtedly worth a great deal to somebody, looking at the specific drainage problem, a great deal more is being pumped than the actual water that causes the damage, because of this underflow in this lower gravel.

Senator ANDERSON. Right there that raises a question that I want to ask you. I recognize you are a drainage expert of the Bureau of Reclamation, and that is why I was going to ask you this question.

I don't understand why it is a question of waterlogging, that water within 3 to 5 feet of the surface. You go down 200 feet in the ground and start pumping out water. Now, will you tell me what benefit that is to water that is up within 3 or 4 feet of the surface?

Mr. MAIERHOFER. Well, as I said, if you pump 15,000 acre-feet annually, you do draw down some surface water, and it reaches out, but we don't know the proportion. We think that the major part of the water you pump has no effect. In other words, only some percentage, comparatively small percentage of the water pumped is providing effective drainage.

To give you an example of what I mean: as between the deep pumping and the subsurface drains, in subsoil conditions such as generally prevail in the valley, 15,000 acre-feet of water could be taken out with—and this is a very rough estimate—$200,000 to $300,000 worth of subsurface drainage construction; and if the drains were properly constructed, the annual costs for obtaining that specific amount of water that is hurting plant roots, would be small compared to costs for accomplishing equivalent drainage by pumping from the deep gravel aquifer.

Senator ANDERSON. How far would you be lifting that water?

Mr. MAIERHOFER. Well, these drains would be not over, say 10 feet deep, so we would be lifting it to ground surface, plus whatever it takes to get it into the river or over the boundary pumping plant. And as I understand, the boundary pumping plant costs are in the neighborhood of 30 cents to 50 cents per acre-foot annually. So if it is pumped there, 25,000 acre-feet, if that is the figure that is causing trouble, why, we are talking about $7,500 annually.

I don't want to minimize the value of the water that is being pumped. Now that is the picture that has been injected only recently. I am sure you understand that clearly. It has a great value to the United States, any water in the Southwest does.

The following conclusions, to summarize this brief, may be drawn: The overall drainage conditions in the valley are no worse since mesa irrigation. The eastern portion of the valley has an additional drainage burden; the western portion has a reduced drainage burden. Specific quantities cannot be determined accurately with available data or at practical cost.

And to summarize our statement, not a summary, but a gesture, we work for the water users and we work for the taxpayers of the United States all over the country, the Geological Survey and the Bureau have joined in a plea to all these people that we try to get an equitable resolution based on scientific data, and only in that manner. We think if that will be done, if the controversy will be worked out on a scientific basis, no one will be hurt and everyone will be benefited. It is a bad thing when someone gets hurt or thinks he is being hurt. We would like to get it cleared up in an engineering manner and do whatever it takes and let someone else decide who caused it. We are not trying to press anything anywhere.

Now that, Mr. Chairman, is a summary of our joint statement. Unless you have anything else you would like to go into, it is all I have.

Senator ANDERSON. Well, I certainly would be delighted to have a chance to study that statement. I am sure that Senator Hayden and Congressman Udall and Senator Goldwater would like to.

It occurs to me that you have made a number of very interesting comments here that I am very much interested in. If there is no significant aggravation to it and no impairment of the productivity, then it would seem to me that what we might be interested in trying to do is find some way where the United States Government might be able to pick up some of this excess water which is very valuable to it in fulfillment of its treaty obligations with Mexico and which could be pumped from low elevations at a very low cost.

This $7,500 a year, and recovering even only a few thousand acre-feet of water, that would go toward the discharge of the Mexican Treaty obligations, and is such a good business deal that the Government couldn't possibly afford to turn it down.

Mr. MAIERHOFER. Understand, Mr. Senator, that $7,500 was for pumping at the boundary pumping plant and assuming that the 25,000 acre-feet which ran into the valley lands were dangerous. The pumping cost from the lower gravel, of course, where you would get your big water supplies, would be more expensive because it is more lift.

Senator ANDERSON. May I ask you this question: If you do not pump these large quantities of water from the lower gravel strata, which is about at sea level, would there not be a tendency that that water, if not intercepted, would just naturally flow into Mexico and you would get no credit for it under the treaty?

Mr. MAIERHOFER. Very definitely. There again, with due respects to my colleague in the engineering profession, Dr. Jacob, we feel that a very high percentage of the deep percolation from mesa irrigation goes into Mexico now, a much greater percentage than is being spoken of.

Senator ANDERSON. Senator Hayden, do you have any questions?

Senator HAYDEN. My attention has been directed to a sentence on page 66 of the Tipton-Jacob report, which says:

> With regard to the flow underground from Yuma Mesa to South Gila Valley, in the light of what has been said with regard to the superposition of states of flow, it should be noted that the quantities quoted in table 5 are net quantities and do not give the absolute magnitude of flow one way or the other.

Senator ANDERSON. That table 5 will be printed at this point in the record.

Second inventory of water imported to Yuma Mesa, 1921 to 1955 *

Year	(1) Imports (1,000 acre-feet)	(2) Consumptive use (1,000 acre-feet)	(3) Recharge (1,000 acre-feet)	(4) Differential volume ΔV (1,000 acre-feet)	(5) $\bar{S}.\Delta V$ [1] (1,000 acre-feet)	(6) Gradient x perimeter south and east $\Sigma I \Delta l$ (feet)	(7) $\bar{T}.\Sigma I \Delta l$ [2] (1,000 acre-feet per year)	(8) Underflow to south and east $T.\Sigma I \Delta l \Delta t$ (1,000 acre-feet)	(9) Total storage under mesa (1,000 acre-feet)	(10) Outflow from mesa (1,000 acre-feet)	(11) Outflow to South Gila (1,000 acre-feet)	(12) Outflow to Yuma Valley (1,000 acre-feet)
1921	18	7	11	17	11	----------	----------	0	11	0	0	0
1925	578	187	391	638	[3] 319	----------	----------	[4] 12	331	60	15	45
1947	290	101	189	141	91	19	5	12	103	86	22	64
1949	305	114	191	123	79	26	7	16	95	96	28	68
1951	440	148	292	316	203	31	9	20	223	69	20	49
1953	520	[5] 200	320	347	223	38	11	24	247	73	22	51
1955						46	13					
Average, 1947–55	389	141	248	----------	149	----------	----------	18	167	81	23	58
Per year	195	71	124	----------	75	----------	----------	9	84	40	11	29

*Table No. 5, Report on Ground Water and Drainage of Yuma Mesa and Yuma Valley; by Tipton & Kalmbach, Inc., and C. E. Jacob; November 1, 1956.

[1] Using $\bar{S}$=0.643 from second analysis of selected area.

[2] Using $\bar{T}$=284 acre-feet per foot-year from second analysis of selected area.

[3] Using $\bar{S}$=0.50 for this item.

[4] Estimated from probable gradient at perimeter in 1945 and 1946 and observed gradient in 1947.

[5] Revised calculation of consumptive use

Senator HAYDEN. I look at that table 5 here and it shows the outflow to the South Gila is an estimated 11,000 net acre-feet and into the Yuma Valley, 29,000 acre-feet.

Do you agree that there is a substantial flow into the North Gila?

Mr. MAIERHOFER. Not North Gila, sir.

Senator HAYDEN. South Gila, I beg your pardon. One is the Yuma Valley and the other is the South Gila that I am talking about. The outflow to the South Gila is 11,000 acre-feet and to the Yuma Valley is 29,000 acre-feet annually.

Mr. MAIERHOFER. We feel that we can't quibble with the estimate that the consultants have come up with regarding the amount that goes into the valley. We have numerous studies. I think I could defend a figure of 10,000 acre-feet to 30,000 acre-feet. I could defend anything in between with equal vigor and substantiation. So therefore we feel, we agree, that the 25,000 acre-feet is in the right range of magnitude.

My personal feeling is that 11,000 acre-feet annually to the South Gila Valley, assuming that it is a direct contribution to the agricultural lands and not to the underlying gravel aquifers, would make the entire area a complete swamp. We only got the report Monday and we haven't had time to study the details. I think Dr. Jacob could clarify whether he means 11,000 acre-feet is flowing into the zone that causes damage to plant roots or whether he means that it is getting into the gravels.

Senator ANDERSON. Senator Hayden, would you excuse me if I ask Dr. Jacob to come up here just a second to try to clarify that, because I saw him shaking his head when you made that comment. The best place to clear that up is here.

Mr. JACOB. I think the sentence that Senator Hayden read clarifies that this is not the actual physical flow, but it is the flow superimposed upon the natural flow. Now in my testimony I testified that the natural flow in 1925, before appreciable irrigation on the mesa, was to the south southwest beneath the mesa in the deep gravel aquifer at a rate of about 750 acre-feet per mile per year. And if you took a 20-mile section east of the river you would get roughly 15,000 acre-feet.

Now, this 11,000 is a component flowing northward superimposed on top of this that is flowing southward. When you get the net result, you know that the water stagnates and we have a point of stagnation, a saddle point, as it were, in the water-table surface just inside the South Gila project today. That means that the water is physically flowing northward from Yuma Mesa to this saddle point and then flowing off to both sides and veering around and then going southward, so that the northward flow is just a local thing at the present time.

Senator ANDERSON. May I just stop you there.

Senator HAYDEN. Mr. Chairman, I think I cut off the South Gila people rather shortly this morning because I wanted to make it clear to you that the hearing was called to consider the controversy between the mesa and the project, but nevertheless it does appear for this record that there is a possibility of substantial water going into the South Gila. Now, what to do about that, it seems to me, is a matter that Mr. Dexheimer will have to consider with the money that we have appropriated to him. It is, however, a grave matter to the people living within the South Gila area.

Senator ANDERSON. Yes, Senator Hayden. I thought of that while I, too, tried to keep that discussion limited as much as possible. However, I do think it is important to find out that if we are going to have this matter before the Congress someday. In that section as well as this section, we might just as well face that problem now and try to see if there are studies which might be made to be useful to us, and from that standpoint I thought it was important and worthwhile.

I do think, however, that the conclusions reached here by the Geological Survey and the Bureau of Reclamation are sufficiently interesting, so that what we need to try to do what has been suggested: find some equitable resolution to this problem so it just doesn't keep us tied up for a long time in controversy.

Congressman UDALL. May I make a suggestion here? I am sure, as Senator Hayden says, none of us intends to give anyone the impression that we are unnecessarily narrowing the inquiry here. Undoubtedly, our hearing has to be brief today. The South Gila people, for instance, and their water expert may want to continue on what has taken place here today. I imagine that, under our usual procedure, the Senator might be willing to have them submit for the record anything additional that they have.

Senator ANDERSON. Oh, not only that, Congressman Udall; I would welcome everything they can give us. I would like to have their comments on this contribution that the Bureau of Reclamation has turned in, and I would think that the best thing we could do is to take what I regard as this very informative paper that the Bureau of Reclamation and the Geological Survey have prepared, check it back as far as Dr. Jacob is concerned with his group, check it back as far as the South Gila people or the Yuma Irrigation District is concerned, and try to give conclusions that we can use and chew over, and then I assure you we will have additional hearings here or in Washington after we have additional studies and try to bring this to some resolution.

Perhaps I am at fault in suggesting that we wanted to keep it to this one particular question, because frankly I have been trying, at the urging and instigation of the Arizona Representatives, to see if we could bring out some sort of harmonious resolution of the problems between the people in the mesa and the people in the valley districts.

Now, if by the 1st day of December, or the 15th day of December, you can get in your comments—I prefer them by the 1st—your comments on this testimony today, I think it would be very, very valuable. I don't know whether the Bureau of Reclamation could make copies of this report so that we could serve them officially on the 3 or 4 interested bodies. Could you do that?

Mr. MAIERHOFER. I have enough copies here, Senator—5 or 6 copies, put it that way.

Senator ANDERSON. Then may I ask that instead of furnishing us with 5 or 6 copies to take back to Washington that you give to Mr. Johannsen, representing the Yuma County Water Users' Association, a copy of the complete text, not your summary, but that you give to him a copy of the complete text; that you give to Mr. Bradley a copy of the complete text; that you give to Mr. Miller a complete copy. If the people in the Wellton-Mohawk district need one, which I don't believe they do as yet, perhaps we can furnish them one, too. But if those 3 agencies—if you could give us 4 copies, that would be fine. We will take the original for our permanent record.

Mr. MAIERHOFER. All right.

Senator ANDERSON. Then if we study this report and the report of the Bureau of Reclamation, and then you supply us with your comments, hopefully by the 1st of December, but not ruled out if they don't come for a few more days, I think it would be a good thing. Would you not think so, Senator Hayden?

Senator HAYDEN. Yes.

Senator ANDERSON. Congressman Udall?

Congressman UDALL. Yes.

Senator ANDERSON. Let's do that. Also may I suggest that if one of these groups wants to get in correspondence with the Bureau of Reclamation and say, "Where is your basis for this?" that it probably would save time. Just as today, you had a question that arose between the Bureau of Reclamation and Dr. Jacobs. It is not difficult to resolve it if a chance is given to explain it. Frankly, I am very hopeful, as I have told Senator Hayden and Congressman Udall and Senator Goldwater, that out of this discussion we may find which route we should take in trying to be helpful. But frankly, when I sit on the committee and hear these different points of view, where one group is absolutely sure that the mesa is dumping water on the valley and is hurting it, and the other group is equally sure that that is not the situation, it is pretty hard for me as a layman to come to much of a resolution on it. If we can get these expert opinions, I think it would be much more useful to all of us. Therefore, I just apologize to you, Congressman, for breaking in on you, but I do want to say that if we supply those three copies and you all supply us with your comments, maybe you will give us some guidance on what to do.

Go ahead.

Congressman UDALL. I have a few questions here.

I frankly am a little bit confused about the testimony that has been presented. I notice your report here, in your testimony a moment ago, that the Bureau of Reclamation believes there is no significant aggravation, and yet the next conclusion is that you believe the mesa contributes to the drainage problem.

Now that seems to me to be saying "Yes" and "No." Do you believe that there is a contribution but that the contribution is insignificant, or do you see any contradiction between the two statements?

Mr. MAIERHOFER. I can understand why you caught that. One of our own people in the Commissioner's office also informed me about it and wanted me to change it, and I couldn't do it because we had done this work jointly, and there was a specific purpose in the language. Both statements are true. They seem diverse because they represent different basic viewpoints of the two agencies.

Now, I tried to bring it out when I was speaking of agricultural damage. We feel, our viewpoint is, that there is no net injury. Productivity is as high as it was before.

Congressman UDALL. You are talking about two different things.

Mr. MAIERHOFER. That is true. It is the viewpoint of two different agencies. The Geological Survey deals with ground water going from here to there; we deal with production of crops and reclamation of lands.

Congressman UDALL. But one of the factors in production is the cost of protecting and preserving lands.

Mr. MAIERHOFER. I agree. I hope we brought that out, that the valley does have an additional burden. They are having to pump water that they would not have to pump if the mesa were not being irrigated.

Congressman UDALL. Well, in that regard, then——

Mr. MAIERHOFER. It is injured.

Congressman UDALL. It is what we might call a significant contribution to the drainage problem?

Mr. MAIERHOFER. I wouldn't say significant contribution. I would say it is a contribution. The 25,000 acre-feet, or whatever it may be, is 2 drops compared to the importation, and it loses significance in magnitude. It is a thing that costs money to take care of. They are taking care of it. If they were not taking care of it, they would have injury.

Senator ANDERSON. May I break in just a second to ask this question: If the importation of this water requires them to pump, is it not true that the water is worth more to the United States in fulfilling its obligations to Mexico under the treaty than the actual cost of the pumping? You and I know the value of water. Therefore, would it not be feasible and worthwhile for the United States to assume some burden of that pumping in exchange for the water which it gets to fulfill its treaty obligations?

Mr. MAIERHOFER. There is no doubt in my mind but what any water that is of suitable quality for use in the southwestern United States is worth just about anything it costs to pump it. I wouldn't go so far as to say that some of the many thousand foot wells in California are economical. They are signs of the times. You can afford it today, you can't tomorrow, you couldn't last year; something of that sort. But any water that can be recovered in this part of the country with the ease with which we can get that water is certainly worth going after.

Congressman UDALL. Now one other conflict, it seems to me, that we have developed here today—and I would like to see the local people comment on that in the reports that they file commenting on the testimony here. From the direct testimony presented on that point this morning, most of the local witnesses are apparently of the opinion, whether it is a scientifically informed opinion or not, at least the best judgment and thinking seems to be that there has been a rise in the water level in the area since the mesa project went into effect. Yet your testimony here is, if I got it correctly, that there is no significant rise in what you call the average water-table level.

Is that a conflict or not?

Mr. MAIERHOFER. I don't think it is a conflict, Congressman. There has been no average rise. There has been a rise in specific areas. Therefore, if there has been a rise in specific areas and there has been no average rise, it means there has been a drop in specific areas to compensate.

Now our feeling, and it is strictly judgment based on the study of the ground-water information we have, is that since the construction of Hoover Dam the Colorado River has had a more favorable regimen and there is now more outflow of ground water from the valley, which formerly caused damage, which compensates for the new inflow from the mesa.

Congressman UDALL. Let me pinpoint the question in this fashion: At the bend, so-called Big Bend area, which is one of the hardest hit

with waterlogging, is it entirely possible that there, at that point, the outflow from the mesa is a major factor and that in other areas, for instance, it might be a minor factor?

Mr. MAIERHOFER. I agree that it could be a very major factor, depending upon which land it is on. We want to remember that some of these lands that have been controversial through the years were never suitable for irrigation. The Yuma Valley has some of the best irrigated land in the West, there is no question about that, but like all irrigation projects, I know of none that do not have some land that should not be irrigated. We call it class VI.

There is lands like that in the Big Bend area. Now whether this damage that is alleged is in the good agricultural lands in that area or whether it is in the lands that were never any good, I cannot say. We have never been able to get damage pinpointed. I would like it pointed out to me and I would like to explore the irrigability of that from the inception of the project.

The Big Bend area was once used for duck shooting. The first time I saw it, it was a marsh. In days before that it was good and it was bad, and my understanding is that it has some heavy soils which are not suitable for irrigation, and those heavy soils, in my experience, is the only place that artesian pressure will ever hurt you. If you are in light soils, loam, sandy loams, even clay loams and silt loams, artesian pressures are not a serious factor.

Congressman UDALL. Now, one other point that occurs to me is that Dr. Jacob seems to be quite willing—maybe he jumped off the deep end in your opinion—to give estimates of the outflow. Is your reluctance due to the fact that you are being more conservative on it, and do you seriously disagree with him?

Mr. MAIERHOFER. No; I don't seriously disagree with anything in that report that is an important conclusion. We agree very much with him, and we think the 25,000 acre-feet in the conclusions is in the right magnitude.

As I understand it, there is an estimate of 29,000 acre-feet annually for a period of 8 years. I want to study that more carefully before I would give an opinion. And while I am on this, I would like to say this, that the only serious error I see in that report is that these 2 men, Tipton and Jacob, had to do a 6-months' job in 1 month. They did a magnificent job. I know personally they worked night and day on it and have put together a great deal of data. So I wouldn't quibble for a second with anything in that report until I had a chance to review it, and we have had only 2 days.

Congressman UDALL. Now just 1 or 2 other points here. You were not stating as a conclusion at all that there was an excessive importation of water on the mesa?

Mr. MAIERHOFER. I didn't mention at all importation of water on the mesa. I was speaking entirely of the valley.

Congressman UDALL. And you are expressing no opinion here concerning whether more water is used than is necessary for the farming operation?

Mr. MAIERHOFER. No; I did not go into that at all. I was speaking strictly of importations to the valley, pumping it at the boundary pumping plant, and then, water going into the valley from the mesa.

Congressman UDALL. Then you have no opinion on that subject?

Mr. MAIERHOFER. Yes.

Congressman UDALL. That is all.

Senator ANDERSON. Are there other questions of either of these witnesses?

We will dismiss these two witnesses.

Let me say that this is a sample of what I regard as a very fine service we have had over a long period of years from the Geological Survey and Bureau of Reclamation. Certainly they are two of the very finest services. I am partial to the Forest Service as well, but they are two of the finest services we have in the Government, and I want to personally express my appreciation for the very fine testimony we have had from all witnesses here today.

We are not going to close things with this, but I do want to say I appreciate it very much.

Did you have a separate statement you wanted to make, Mr. Harshbarger?

Mr. HARSHBARGER. No.

Senator ANDERSON. This was regarded as a joint venture. Maybe you had better identify yourself for the record, Mr. Harshbarger. I didn't mean to cut you out.

Mr. HARSHBARGER. My name is John Harshbarger, district geologist for the ground-water branch, State of Arizona, United States Geological Survey. I hold a degree in engineering and doctor's degree in geology, and was formerly on the staff of the University of Arizona. For the past 7 years I have been with the United States Geological Survey.

Senator ANDERSON. And do I understand that you participated in the preparation of the historic statement that was read today?

Mr. HARSHBARGER. Yes.

Senator ANDERSON. And do you generally subscribe, or do you in general subscribe to the testimony given by the Bureau of Reclamation here?

Mr. HARSHBARGER. Yes, sir.

Senator ANDERSON. Thank you. Senator Hayden, do you have a question?

Senator HAYDEN. No.

Senator ANDERSON. Mr. Udall?

Congressman UDALL. No.

Senator ANDERSON. Now may I try the dangerous expedient of asking if there are people in the group here who have questions that you think we can dispose of in the first day? I don't wish to unduly prolong the hearing, but if somebody says in his own mind, as I did one time when I went to a water hearing, "Why didn't somebody ask him this?" now is a good time to get it out of your system.

I remember I went to a water hearing one time, and I wasn't getting any water at all on my farm. They asked all the rest of the questions except why I wasn't getting any water on my farm. That was the only question I wanted answered.

If you have a question that you think will contribute anything, fine. If not, thank you very, very much for being a wonderfully fine group. Thank you for the arrangements that have been made here.

I want to express my appreciation to everybody from the Yuma area for extending facilities to us, and for the very nice way in which you organized your work in advance.

May I say, too, that one of the things which we have the greatest difficulty with in Washington is the fact that people will not brief

their comments and get them to us in a reasonable period of time. I hope you appreciate the fact that Dr. Jacob in presenting his statement covered in a very short time a great deal of work. Now we have this presentation from the Bureau of Reclamation and the Geological Survey covering a great deal of study and presented in a very short time, and I think as chairman of this subcommittee I should express my appreciation to them, and say to you that this problem has bothered Congress for a long time, and we intend to try to see what we can do to be of assistance to you in this very important problem.

Thank you all.

(The following was subsequently received for the record:)

SUPPLEMENTAL STATEMENT OF THE YUMA VALLEY WATER USERS ASSOCIATION

Hon. CLINTON P. ANDERSON,
Chairman, Subcommittee on Irrigation and Reclamation,
Committee on Interior and Insular Affairs,
Senate Office Building, Washington, D. C.

DEAR MR. CHAIRMAN: Pursuant to your request, during the hearing on November 8, 1956, in Yuma, Ariz., that we review the testimony and the statement of Mr. Maierhofer, Bureau of Reclamation, we herewith offer our comments for the information and consideration of the committee.

Unquestionably, the Maierhofer statement is a very informative report, which, of course, represents the Bureau's views on the drainage problem. We offer our comments in a constructive manner, fully recognizing the committee's desire to consider the real issues confronting the valley division, namely, first, groundwater outflow from the mesa to the valley division, and second, remedial measures necessary to protect those lands affected by mesa outflow.

The second paragraph of the joint statement (p. 1) sets forth the Bureau's position and the survey's position and states that these two views are not in conflict. We agree with the survey's position that irrigation on the mesa contributes to the drainage problems in some parts of the valley. We add to this—those areas adjacent to the base of the mesa.

The next paragraph points up four important contributions that promote a better understanding of the relation between irrigation on the mesa and drainage in the valley. On the first point it is encouraging to note that the Bureau, the survey, the valley division, and the private engineers, Tipton & Kalmbach, Inc., and C. E. Jacob are in complete agreement. Point 1 reads as follows:

"1. A coarse-gravel zone of high permeability, occurring approximately at sea level in the Yuma area, extending under both the mesa and the valley, and averaging several tens of feet in thickness, was identified."

No. 2 reads as follows:

"2. Electrical analog studies made through the Big Bend area show that the coarse-gravel zone can be highly effective in transmitting head changes resulting from irrigation on the mesa."

We are in agreement on No. 2. Point No. 3 embarks on a lengthy technical discourse on head changes. The fact that head changes are in evidence and adversely affect drainage in the valley division is the issue before the committee and No. 3 confirms this point. Point No. 4, when boiled down, states that a complete accounting of all water movement in the area is not justified. We believe this is a matter for the committee to decide. We further believe that the private engineers have given an accounting of the water movement in the area.

The second paragraph on page 2 reads as follows: "The available data do not reveal whether, in specific problem areas, the particular cause of aggravated drainage problems has been excess application of irrigation water, actual upward seepage of water from the coarse-gravel zone, or loss of drainage opportunity through establishment of adverse head gradients."

Our comment: The committee has already been supplied with data on the amount of irrigation water applied in specific problem areas. We enclose same data again (see enclosed folder),[1] to indicate that the drainage problem arises from one, or both, of the other two causes mentioned in the Bureau's answer.

We now add our comments to the 10 questions and answers beginning on page 2 and continuing to page 7.

[1] Retained in committee files; not printed herein.

1. "Has there been a rise in the average elevation of the water table, throughout the valley lands, since the beginning of irrigation on the mesa?"

"The record is given in the following table, wherein the averages have been determined by the method of Thiesson polygons using selected wells throughout the valley.

Year and average water-table elevation

1942	99.5	1949	99.8
1943	99.4	1950	99.4
1944	99.3	1951	99.2
1945	99.6	1952	99.6
1946	99.5	1953	99.1
1947	99.2	1954	99.5
1948	99.8	1955	98.9"

Our comment: The west side of the valley division could easily experience a further lowering of the water table with the drying up of the Colorado River plus a hundred irrigation wells pumping immediately across the river in Mexico. This would balance out a comparable rise in water table on the east side of the valley division at the base of the mesa. The average remains the same—hence, no rise in average water table. The average does not describe the specific area, and we believe the committee is mainly concerned with the affected area at the base of the mesa.

2. "Has there been a rise in the average elevation of the water table throughout the east half of the valley, between the mesa and the central main drain, since irrigation began on the mesa?

"The record is given in the following table wherein the averages have again been determined in the manner already described.

Year and average elevation

1942	101.3	1949	101.8
1943	101.0	1950	101.6
1944	101.1	1951	101.5
1945	101.6	1952	101.6
1946	101.8	1953	101.4
1947	101.4	1954	102.0
1948	101.7	1955	101.9"

Our comment: The average does not describe the specific area.

3. "Has there been a rise in the average elevation of the water table in specific areas of the valley since irrigation began on the mesa?

"Water-table elevations show a persistent rise in the northeastern part of the valley south of Yuma and in an area southwest of the Big Bend area. The maximum rise observed in either areas has been about 2 feet since 1942. In both areas the present depth to ground water is about 3 feet along the East Main Canal, about 8 to 11 feet some 4 miles west of the canal. In the history of both areas there is evidence of occasional higher ground-water elevations."

Our comment: The 2 areas mentioned are without adequate drainage facilities for 2 reasons. First, they are experiencing less damage compared to other areas. Second, we are lacking in funds.

4. "Has there been a reduction in irrigable lands in the valley since mesa irrigation?

"The irrigable acreage has increased and the area out of production due to adverse drainage conditions has decreased, as shown by the following data from the Annual Project Histories:

Year	Total irrigable acreage	Acreage out of production due to adverse drainage conditions	Year	Total irrigable acreage	Acreage out of production due to adverse drainage conditions
1940	49,135	1,090	1947	48,787	1,603
1941	49,271	1,106	1948	49,705	685
1942	49,068	1,163	1949	49,555	835
1943	49,251	1,184	1950	52,591	400
1944	49,273	1,173	1951	52,591	400
1945	49,216	1,173	1952	51,510	0
1946	49,083	1,307	1953	51,936	0"

Our comment: Irrigable acreage in the valley division has increased mainly because of new land brought into production on the west side of the valley, some by homestead and some by sale of Government lands. Area out of production increased rather than decreased when mesa irrigation started on a large scale. Note the increase from 1945 through 1947. The first large-scale program of wells was started in 1947; hence the decreased acreage in 1948 continuing through 1950 while irrigation on the mesa was not increased. From 1951 on we offer our own records for acreage out of production due to adverse drainage conditions.

Year	Total irrigable acreage	Acreage out of production due to adverse drainage conditions
1951	52,591	138.2
1952	51,510	440.01
1953	51,936	500.77
1954	51,130	785.63
1955	51,302	776.98
1956	51,371	764.98

These figures were established by action of the board of governors and are public information.

5. Has there been an increase in net water imported to the Valley Lands since Mesa irrigation?

"The record is given in the following table:

Year and net water imported exclusive of deep well pumping

	Acre-feet		*Acre-feet*
1941	230,000	1949	270,000
1942	230,000	1950	280,000
1943	250,000	1951	290,000
1944	240,000	1952	300,000
1945	240,000	1953	290,000
1946	270,000	1954	290,000
1947	270,000	1955	280,000"
1948	270,000		

Our comment: Net increase in water imported has been .2 of an acre-foot in the last 10 years as the figures in the statement show.

6. "Is this increase due to increased water applications?

"The following table shows the net water imported in terms of acreage irrigated, excluding water pumped from deep wells:

Year and net water imported

[In acre-feet per acre irrigated]

1942	5.0	1950	5.9
1943	5.4	1951	6.3
1944	5.3	1952	6.3
1945	5.3	1953	6.2
1946[1]	5.9	1954	6.4
1948	5.8	1955	6.1
1949	5.8	1947[1]	5.9

"Some of the water obtained by pumping the deep wells can be considered a net import into the valley; best engineering judgment indicates that it is a substantial portion. Total volume pumped in 1955 was about 15,000 acre-feet, but available data do not permit estimates of the portion coming from outside the valley."

Our comment: Please note that net water imported per acre has decreased since the association has taken over the operation of the Valley division.

7. "Has the volume of water pumped at the Boundary pumping plant increased since irrigation began on the mesa?

"The increase in pumping at the Boundary pumping plant accompanies the increase in net water imported to the valley. The following table shows a comparison between net water imported per acre irrigated, and water pumped at the Boundary plant per acre irrigated.

Year	Acres irrigated	Net water imported, acre-feet	Pumped at Boundary pumping plant		Net water imported, acre-feet per irrigated acre
			Total acre-feet	Acre-feet per irrigated acre	
1942	46,000	230,000	70,000	1.5	5.0
1943	46,000	250,000	70,000	1.5	5.4
1944	45,500	240,000	65,000	1.4	5.3
1945	45,500	240,000	55,000	1.2	5.3
1946	46,000	270,000	70,000	1.5	5.9
1947	45,500	270,000	90,000	2.0	5.9
1948	46,500	270,000	85,000	1.8	5.8
1949	46,500	270,000	95,000	2.0	5.8
1950	47,500	280,000	90,000	1.9	5.9
1951	46,000	290,000	90,000	2.0	6.3
1952	47,500	300,000	110,000	2.3	6.3
1953	47,000	290,000	110,000	2.3	6.2
1954	45,500	105,000	105,000	2.3	6.4
1955	45,500	280,000	105,000	2.3	6.1"

Our comment: We have no disagreement over these figures. We do not know how they are related to the real issue.

8. "Does the ground-water flow from the mesa to the valley appear in the increased pump load at the Boundary pumping plant?

"An unknown quantity of ground water undoubtedly flows from the mesa, some of which reappears as shallow ground water in the valley and some leaves the general Yuma area through the deep-gravel aquifer. The contributions to the shallow ground water constitute an added burden on the valley drainage system. Concurrently an additional burden has been imposed by the valley itself in the form of substantially increased water imports and heavier applications per acre. Considering the entire valley the increased pumping load at the Boundary pumping plant is consistent with the increased imports. Two other factors pertinent to the problem are contributions from the mesa on the east, and increased outflow to the Colorado River on the west due to improved channel conditions from the Hoover Dam operations. These are plus and minus factors of about the same magnitude."

Our comment: Apparently the answer is "Yes." In that case, we agree.

9. "Can the ground-water flow from the mesa to the valley be isolated and accurately estimated?

"The available data do not permit an estimate. Even additional data obtained at prohibitive costs would permit only an approximation."

Our comment: It is difficult to understand the Bureau's insistence that the answer is "No," when private engineers have definitely come up with an answer, and the Bureau's chief drainage engineer, Mr. Maierhofer, does not disagree. The estimated flow is in the record and the cost was certainly not prohibitive.

10. "Have drainage measures taken by the valley prevented damages which would otherwise have occurred because of irrigation on the mesa?

"Some portion of the water pumped from the wells tapping the coarse-gravel zone has prevented damages in some areas. There is reason to question whether these measures constitute the most economical method of drainage relief.

"With reference to the specific problem—whether water applied for irrigation on the mesa affects the drainage problem in the valley—the following conclusions may be drawn:

"1. Overall drainage conditions in the valley are no worse since irrigation began on the mesa.

"2. The eastern portion of the valley has experienced an additional drainage burden; the western portion has experienced a reduced drainage burden due to the changed regimen of the Colorado River.

"3. Specific quantities involved cannot be determined accurately with data available or data which could be obtained at practical cost."

Our comment: We seem to be in agreement on well pumping as a means of preventing damage to valley lands. We further agree with the Bureau in questioning whether these measures are the most economical methods of drainage correction. It is difficult to understand how the Bureau can make the above statements, and then say we have no drainage problem resulting from mesa irrigation.

Subsection 1. We do not seek to burden the committee with our overall problem—only the specific area along the base of the mesa.

Subsection 2. Let's confine our problem to the eastern portion of the valley along the base of the mesa.

Subsection 3. The Bureau states what it cannot do; but private engineers have already done the job under specific instructions from the Secretary of the Interior.

The first paragraph on page 7 and following subsection 3 seems to imply that the cost of adequate drainage works would be cheaper than the cost of determining how much water is causing the trouble.

Our primary purpose is to develop adequate drainage works for the protection of valley lands, and if this can be accomplished by foregoing the cost of determining what is causing the trouble, we are not one to question methods.

We are in complete accord with the final sentence of the statement. We assume that all parties have accepted the report of the independent engineers Tipton & Kalmbach, Inc., and C. E. Jacob.

During the course of the hearing it became evident that information was lacking on the planning reports prior to authorization of the mesa project.

We offer for the committee's information certain excerpts from a Department of the Interior publication bearing the title of "Report of the Feasibility of Gila Valley Project, Arizona, by Special Committee, February 1936." The authors are W. H. Code, William Peterson, and W. L. Powers.

Under the synopsis on page (c) we quote: "The engineers report that four acre feet an acre, which appears to be a suitable supply for these lands." Farther down toward the bottom of the page we quote: "A subsidiary supply of water for large areas as in North Mohawk and South Gila Valleys may be most economical, securable from wells where water is of good quality. Its pumping will increase drainage insurance."

On the following page (d) we quote: "Desilting of Colorado River water at Imperial Dam may be deferred at least in part for a decade or so to permit incorporation of some silt for soil improvement in the sandy area of the Yuma Mesa." Farther down on the same page we quote: "Yuma Mesa soils are sandy, have excellent drainage."

Under "Conclusions and recommendations" on page (f) we quote: "1. Project should utilize mainly class one lands first which can be made promptly profitable and should not be confined to mesa units." On the same page, under section 3, we quote: "Silting sandy land is necessary for 8 or 10 years."

Incorporated in this same report is a part of the Johnson report made in June 1932. From that part of the Johnson report on page 23 we quote: "Drainage conditions are difficult to predict on so large a project. The fact that the present ground water is several hundred feet below the surface of the mesa lands has led to many predictions that drainage will never be a problem on the mesa lands. It is reported, however, that this same condition held true in the Salt River project in 1905 but by 1912 it was necessary to provide artificial drainage."

We hope the above excerpts will be helpful to the committee in establishing background information on water use and drainage for the mesa.

No doubt the 4 acre-feet per acre water requirement mentioned by the engineers was based on some experience, and also based on the Colorado River remaining muddy for several years. Unfortunately, the Colorado River was cleared up and lost that soil component so essential for properly reclaiming sandy mesa land. This brought about a much greater water requirement for mesa lands, and the inevitable drainage problems logically followed.

Again, Mr. Chairman, we must emphasize the seriousness of our problem. We have already reached the "end of the row" in trying to control mesa groundwater outflow with our own financial resources. The private engineers' report points out that for the last 8 years we have not been removing all the outflow

from the mesa. We believe the committee should give reasonable consideration to the farmer's opinion on whether or not his lands have suffered damage from high ground water and salinity. A substantial number of these affected farmers have been on the land for 25 years or more, and certainly no one is more qualified to judge when the productive capacity of his land has been impaired because of high ground water and salinity.

We have suggested the possibility of intercepting this mesa ground-water outflow by a series of wells along the east side of the valley division and constructing a concrete lined canal to deliver this water to the Mexican boundary. Mr. Chairman, in the November 8, 1956, hearing in Yuma, Ariz., you asked Mr. Maierhofer this question: "If you do not pump these large quantities of water from the lower gravel strata, which is about at sea level, would there not be a tendency that that water, if not intercepted, would just naturally flow into Mexico and you would get no credit for it under the treaty?" Mr. Maierhofer answered, "Very definitely. There again, with due respects to my colleague in the engineering profession, Dr. Jacob, we feel that a very high percentage of the deep percolation from mesa irrigation goes into Mexico now, a much greater percentage than is being spoken of."

Referring back to the hearing on S. 1689 in Washington last June 30, 1955, Mr. E. G. Nielson, Bureau of Reclamation, makes this statement regarding return flow from the mesa. "Now the Yuma-Mesa return flow, so far as we are able to determine, does not accrue to the river within the United States. Your question is, 'Where does it go?'" Mr. Nielson answered, "It goes south into Mexico through the land."

Our question is, Does Mr. Maierhofer agree with the statement of Mr. Nielson that the deep percolation from mesa irrigation goes south into Mexico? If not, then does it go under the Yuma Valley through the coarse gravel aquifer and then into Mexico?

Under direct questioning by Congressman Udall in the November 8, 1956, hearing in Yuma, Mr. Maierhofer admits we are being injured by high ground water resulting from irrigation on the mesa. He admits we are spending money to prevent damage to valley lands. In that same hearing he also says the Bureau's viewpoint is that there is no net injury.

When questioned by the chairman on the feasibility of pumping this drainage water for fulfilling treaty obligations to Mexico, Mr. Maierhofer readily agreed that such an undertaking is feasible.

Going back to the hearing on S. 1689 in Washington last June 30, 1955. When Mr. E. G. Nielson is questioned regarding the pumping of this water for fulfilling treaty obligations he answers as follows: "We would gain a lot of water, but we would have an almost impossible physical job to do."

In the November 8 hearing Mr. Maierhofer agrees with the private engineers that 25,000 acre-feet per year is the annual outflow from mesa to valley.

In the June 30, 1955, hearing on S. 1689 in Washington, Mr. T. P. Ahrens, ground-water engineer for Bureau of Reclamation, states that 3,000 acre-feet per year is the ground-water outflow from mesa to valley, according to the Sweet Report, 1952.

The several preceding statements indicate rather conflicting viewpoints within the Bureau itself, and leaves the association in the difficult position of naturally taking exception to one viewpoint or the other—if not both.

Another example of a conflicting viewpoint between the Bureau and the Valley division (association) is where we present a program, based on the judgment of our engineers, for the removal of this drainage water, and the Bureau, based on the judgment of their engineers, states that we have no overall damage.

The fact that independent engineers have come up with answers to certain phases of this problem, which has brought all parties into agreement, leads us to believe that the independent engineers should continue their investigations with regard to a feasible method of removing this drainage water consistent with the maximum benefits accruing to the United States in fulfilling Mexican Treaty obligations.

On page 2 of the report by Tipton & Kalmbach, Inc., and C. E. Jacob under the title, "Introduction," the instructions from the Secretary of the Interior read as follows: "Estimated cost of remedial action and construction." If these instructions are carried out, we hope that the report of independent engineers will again bring all parties into agreement, and that a peaceful and final settlement of this drainage problem can be made on a scientific and unbiased basis.

Mr. Chairman, it is the most urgent plea of the association, representing the farmers of the Valley division, that the work of these independent engineers be

continued, especially in view of the notable accomplishments resulting from the work they have already done, and the very apparent nearness to a final resolution of this long standing controversy.

Pursuant to your request for a cost breakdown on deep well pumping, our statement follows. We point out here that depreciation, listed for 10 years, will have to be determined by experience.

Well location	Acre-feet pumped per year	Installation cost	Yearly depreciation (10-year basis)	Yearly depreciation per acre-foot	Power cost per acre-foot	Total cost per acre-foot
14½ St.	8,020	17,681.29	1,768.13	0.22	0.18	0.40
13th St.	9,100	18,989.11	1,895.91	.208	.245	.453
12¼ St.	6,450	14,792.40	1,479.24	.229	.316	.545
10¾ St.	7,800	14,218.77	1,421.88	.182	.244	.426
9¾ St.[1]	4,300	7,057.13	708.71	.165	.25	.415
17½ St.	7,200	19,542.49	1,954.25	.271	.24	.511

[1] Old pump, motor, and transformers not charged to this well.

$38,732.02 cost of constructing new power lines and substations for drainage wells. This amount not included in above costs.

In addition the above costs do not include any charge for overhead expense.

We thank the committee for this opportunity to offer our comments.

Yours very truly,

ERNEST M. JOHANNSEN, *President.*

SUPPLEMENTAL STATEMENT OF THE YUMA IRRIGATION DISTRICT

JENNINGS, STROUSS, SALMON & TRASK,
Phoenix, Ariz., December 11, 1956.

Re: Yuma Irrigation District (South Gila Valley), drainage matter.

Senator CLINTON P. ANDERSON,
Committee on Interior and Insular Affairs,
Senate Office Building, Washington, D. C.

DEAR SIR: At the close of the November 8 hearing before your committee, there was serious doubt in the minds of the officials of the Yuma Irrigation District (South Gila Valley) as to the necessity or advisability of a supplemental statement. This question was unresolved until only a few days ago when information became available which conclusively shows that the South Gila Valley (Yuma Irrigation District) is confronted with a present emergency rather than a trend.

A landowner in the area reported to the officials of the district that water was standing in postholes at 28 inches and was rapidly approaching the ground surface in the area. The district officers, on examination of the area, found, to their amazement, that the statements were correct, and, in addition, found permanent water in an ensilage pit on nearby property. By visual examination they also discovered a substantial area on which crops are not growing.

The local office of the Bureau of Reclamation was immediately notified and Bureau personnel promptly proceeded with measurements of water levels in existing test wells in the area and, furthermore, installed a substantial number of new test wells in the immediate area and measured the static level of water in these new wells. (It is interesting to note that no irrigation water has been applied to the particular land in question since October 1, 1956.)

The Bureau's measurements and findings confirm the belief of the district officers and indicate that the ground water of the area is rising much more rapidly than had been expected.

A map or plat, prepared by the local Bureau of Reclamation office, showing the depths to ground water from the surface of the earth at the particular well location is atttached hereto as exhibit A. The area covers the particular area hereinabove referred to. All test wells are indicated by an O. The edge of the valley (north edge of Yuma Mesa) is indicated by a broken line. Below this broken line are 3 wells which we have circled in red and numbered 1, 2, and 3. These have been installed and regularly checked by the Bureau on a quarterly basis since 1945. Readings from these particular wells from 1945 to date have been

tabulated by the Bureau of Reclamation on the attached exhibit B with the well numbers corresponding to exhibit A at the top of the proper column.

This exhibit B clearly shows the trend since water was applied to the Yuma Mesa for irrigation and, furthermore, clearly shows that the emergency in this area exists now—that the trend has become a condition!

In order to determine this condition with more precision, the Bureau of Reclamation installed other test wells, determined static levels and established the interrelation of these readings, all as appear on exhibit A. (It should be observed that the information on exhibit A shows only depth from surface to static water level of the particular well and does not purport to correlate readings from sea level to the ground water table. Consequently, test wells within a short distance of each other may show a substantial difference by reason of a different ground elevation at the well locations.)

The present indications seem to be that the water table is rising much more rapidly than ever before. This possibility is indicated in the recent Tipton & Jacobs Report where the statement is made that if the large surface importation to the Yuma Mesa is continued the reservoir under the Mesa inevitably will become full after which time at least 160,000 acre-feet of water per year must find its way as subsurface flow to adjacent low lying areas, including the Yuma Valley, South Gila Valley and contiguous areas in Mexico. (See conclusion No. 4 on pp. 70 and 71.) It may well be that this condition has now been reached and that these present showings on the attached exhibits are the beginning of the spill in excess of ground water reservoir capacity under the Yuma Mesa. In any event, high ground water is present on the Yuma Mesa side of the South Gila Valley and was not placed there or contributed to by the Yuma Irrigation District or the landowners within its boundaries. Remedial measures must be taken in the South Gila Valley at once. This area is now in the position where it cannot wait for additional surveys and examinations of other projects and adjoining areas. It does not now have the two year grace period originally thought to be possible.

In addition to the disheartening information set forth above, the district officers have, within the last 10 days, received other limited but important information or data in connection with the anticipated salt problem which they and others feel will occur with the full-scale application of irrigation water on the Welton-Mohawk lands. A recent test of 2 water samples from a well drilled 2 miles northeast of Dome and approximately 5 miles from the narrows was made within the last 2 weeks by the president of the Yuma Irrigation District, and the 2 samples were found to contain about 6,000 parts per million of salts. These samples were taken from a thick gravel aquifer after pumping by compressed air for several minutes. The first was taken from a depth of 150 feet below the surface and the second from a depth of 161 feet. The method used to determine the total soluble salts was by electrical conductivity with a "Solubridge." There is no doubt in the minds of those qualified to speak on the subject that these salt-laden waters of the Gila underflow constitute a most serious phase of the problem under consideration.

As far as the Yuma Irrigation District is concerned, there seems to be little, if any, argument as to its right to relief without cost to itself or its landowners, or its right to protection from the ground waters of contiguous or adjacent reclamation projects. Furthermore, it is our opinion that there is little, if any, question as the record of this matter now stands, as to the justification of expenditures for this project by the United States of America. However, on the subject of justification we desire to supplement the matters now in the record on this phase of the case by directing the attention of the committee to Public Law 469 of the 79th Congress, chapter 517, 2d session, commonly referred to as the Colorado River Front Work Act. This act, as now amended by the act of June 28, 1946 (60 Stat. 338), authorizes the annual appropriation of,

> "* * * such sums as may be necessary, to be spent by the Bureau of Reclamation under the direction of the Secretary of the Interior, to defray the cost of (a) operating and maintaining the Colorado River front work and levee system in Arizona, Nevada, and California; (b) *constructing, improving, extending, operating, and maintaining protection and drainage works and systems along the Colorado River;* * * *." [Italics ours.]

It would appear from the history of this legislation that the recent amendment was enacted in connection with the type of problem now facing the Yuma area, and that Congress recognized the potential drainage problems to be created in connection with the construction and operation of Boulder Dam and its connected facilities. The experience of the Bureau of Reclamation over a period

of many years shows conclusively and without exception that drainage always follows reclamation. With this knowledge in mind Congress assumed the responsibility in connection with the Colorado River development of constructing, improving, extending, operating, and maintaining protection and drainage works and systems along the Colorado River.

That bridge having now been crossed we respectfully urge that the coming session of Congress make such appropriation as is necessary "to be spent by the Bureau of Reclamation under the direction of the Secretary of the Interior" to protect the lands of the Yuma Irrigation District from the waterlogging effects of Hoover Dam waters imported into the area's nearby reclamation projects.

I should like to conclude this statement by clearing up the matter of our appearance in this proceeding—if clarification is still necessary. Although we were formally invited by the committee to appear and tell our story at the hearing, some question apparently seemed to arise as to the propriety of our participation. This may have resulted from a misconception of the physical facts of the problem and the location and interrelation of the underground waters of the entire Yuma area. We hope that the physical aspects of the problem have now been cleared up by the testimony and reports introduced into the record of this matter and that the Congress, when considering this problem, will recognize that the problem, as distinguished from the remedy, is not limited to the Yuma Valley area but is regional in scope. As stated in conclusion No. 5 on page 71 of the Tipton & Jacobs report,

> "The problem is not local but regional. The hydrologic regimen involved now and that will be involved to a greater extent in the future, includes the Welton-Mohawk area, the South Gila area, the Yuma Mesa, the Yuma Valley and parts of Mexico. * * *"

The remedy, of necessity, cannot be accomplished on a regional basis. It must be tailored to fit the facts and needs of the particular area involved.

The distinction, if one exists, between the position of the Yuma Valley Water Users' Association and the Yuma Irrigation District, is that the Yuma Irrigation District makes no net contribution to the underground water supply in the district area nor in the entire Yuma area, inasmuch as its source of irrigation water is from electrically operated pumps pumping from deep wells, while on the other hand the Yuma Valley Water Users' Association has one of the oldest and best surface water rights on the Colorado River and irrigates its land by application of Colorado River water. Notwithstanding this lack of net contribution to the underground water supply, there has been a constant rise in the underground water table under the Yuma Irrigation District since the middle forties and a constant increase in the salt content of the water. This condition has been and is coincident in time with the irrigation development of contiguous areas.

There is agreement among all persons, organizations and agencies that the Yuma Irrigation District's ground-water problems are (1) not of its own making, and (2) that drainage facilities will be required in the immediate future if the area is to remain under cultivation.

In fact this area of agreement does not seem to be anything particularly new. The problem was anticipated in the Report of the Feasibility of the Gila Valley Project submitted to the Secretary of the Interior on February 15, 1936, by W. H. Code and others. Undoubtedly this information was in the hands of the Congress when the Yuma Mesa project was authorized. The very problem which faces us today was anticipated and recognized in this 1936 report. We direct your attention generally to the entire report and specifically to a sentence appearing on page 41 which states:

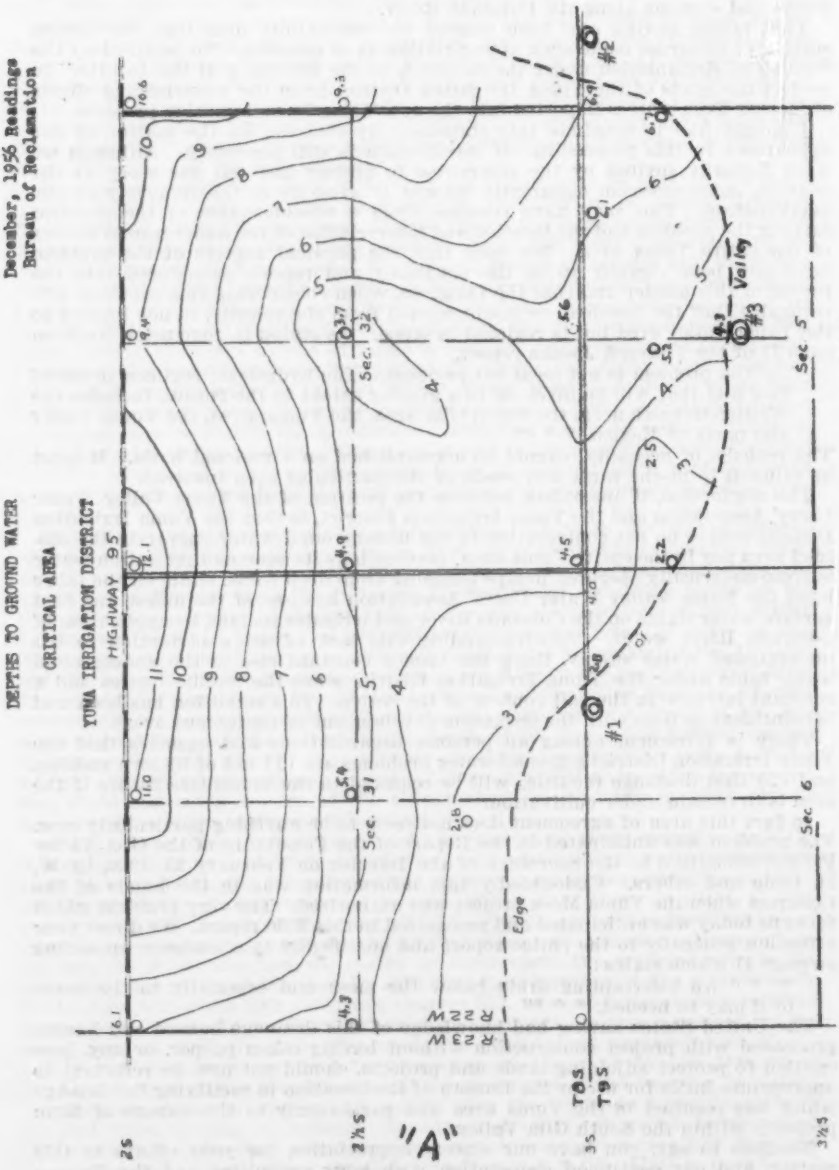
> "* * * An intercepting drain below the mesa and especially to the north of it may be needed. * * *"

The United States having had knowledge of this drainage hazard and having proceeded with project construction without having taken proper, or any, precaution to protect adjoining lands and projects, should not now be reluctant to appropriate funds for use by the Bureau of Reclamation in rectifying the damage which has resulted in the Yuma area and particularly to the owners of farm property within the South Gila Valley.

Needless to say, you have our sincere appreciation for your efforts in this matter, and our continued cooperation with your committee and the Bureau of Reclamation can be relied upon.

Very truly yours,

JENNINGS, STROUSS, SALMON & TRASK,
By J. A. Riggins, Jr.
J. A. RIGGINS, Jr.,
Attorneys for the Yuma Irrigation District.



Attachment to supplemental statement of Yuma Irrigation District, December 11, 1956.

Depths to ground water, South Dila Valley wells, Bureau of Reclamation well readings[1]

	No. 1 3 S., 3½ E.	No. 2 3 S., 5¼ E.	No. 3 3½ S., 4½ E.		No. 1 3 S., 3½ E.	No. 2 3 S., 5¼ E.	No. 3 3½ S., 4½ E.
1945—March				1951—March	15.7	20.0	18.3
June				June	16.3	20.1	18.3
September	26.7	29.2	28.5	September	15.5	19.3	17.0
December	26.6	28.9	28.3	December	14.7	18.3	15.9
1946—March	26.2	29.1	28.2	1952—March	13.2	17.5	15.5
June	26.2	29.2	28.2	June	13.5	17.7	15.3
September	25.8	28.6	27.5	September	14.1	18.2	14.7
December	24.8	27.3	26.2	December	12.4	15.9	13.1
1947—March	23.8	26.9	25.7	1953—March	10.0	15.1	12.6
June	23.7	27.2	25.5	June	10.7	15.7	13.3
September	22.8	25.8	24.2	September	10.9	15.9	12.9
December	21.7	24.6	22.7	December	8.8	13.4	10.3
1948—March	20.4	24.0	21.9	1954—March	7.9	13.2	10.8
June	19.7	23.9	21.5	June	8.8	14.4	11.5
September	19.1	23.4	20.8	September	8.7	13.8	10.1
December	18.2	22.3	19.9	December	6.2	11.2	7.6
1949—March	17.4	21.0	18.8	1955—March	5.4	10.9	8.1
June	17.3	21.6	19.7	June	6.4	12.1	9.1
September	17.1	21.5	19.4	September	5.4	10.6	7.3
December	17.1	21.8	19.7	December	4.1	9.0	5.5
1950—March	16.5	20.7	18.8	1956—March	3.4	7.8	5.7
June	16.7	21.1	19.3	June	4.8	9.6	7.2
September	16.4	20.7	18.9	September	4.1	8.8	6.0
December	16.0	20.0	18.1	December	2.8	6.9	4.3

Attachment to supplemental statement of Yuma Irrigation District, December 11, 1956.

(Whereupon the hearing was concluded.)

○

Attachment to supplemental statement of Yuma Irrigation District, December 11, 1956.